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Contract Report
CR 96.013

ADVANCED MODULAR LIGHTERAGE/PLATFORM TECHNOLOGY DEVELOPMENT -- FINAL REPORT

An Investigation Conducted by

M. Rosenblatt & Son, Inc.
Naval Architects and Marine Engineers
New York NY 10013

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Naval Architects and Marine Engineers
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This report documents a conceptual design effort for the Amphibious Cargo Beaching (ACB) Lighter, a modular barge system which is being developed to replace the Navy Lighter (NL) pontoon causeway system. The ACB Lighter will be rapidly deployed from an auxiliary crane ship and be assembled and operated in sea conditions through sea state three to support Joint Logistics Over the Shore (JLOTS) operations. The primary objectives of this Phase I effort were: (1) the review of pertinent code and non-code hull design procedures for applicability to the development of an acceptable and practical design criteria for the ACB Lighter structure; (2) preliminary structural design of the module to verify the feasibility of developing a light but durable hull structure within the 30 long ton handling weight limit set for each lighter module; (3) selection and arrangement of lighter fittings for handling, stacking, cargo tie-down, and mooring; (4) development of intermodal requirements for module stowage, stacking and handling; and (5) development of a preliminary arrangement for the modular ACB Lighter.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Con't)

LIST OF FIGURES

LIST OF FIGURES (Con't)

LIST OF TABLES

LIST OF TABLES (Con't)

REFERENCES

1. "Amphibious Cargo Beaching (ACB) Lighter Feasibility Design" by Kit Mack of NFESC Design Branch, Code ESC124.

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EXECUTIVE SUMMARY

This report documents the results of a first phase effort by M. Rosenblatt & Son, Inc. (MR&S) which addressed several critical issues germane to the Advanced Modular Lighterage/ Development Program. The key building block of this program is the modular Amphibious Cargo Beaching (ACB) Lighter, being developed by the Naval Facilities Engineering Service Center (NFESC).

The new ACB Lighter is to overcome the many limitations that the existing Navy's NL and the Army's MCS systems have in cargo capacity, freeboard, transportability and operating capability in higher than Sea State 2 weather condition. The new ACB Lighter will be able to operate in Sea State 3 weather condition. Transportability of the new system will be greatly improved by the modular design whereby the 120 ft long by 24 ft wide by 8 ft deep ACB Lighter will be assembled from three 40 ft long modules. The 40 ft modules will be capable of being transported and stacked in 40 ft container cell guides of a containership.

As a key design objective for the handling, transportation and stacking of the modules, the maximum gross handling weight (structure, attached fittings and connector assemblies) for each module was set at 30 long tons (67,200 lbs) the same as the maximum gross weight of a standard 40 ft ISO container.

Under this contract MR&S has been tasked by NFESC Code ESC31 to address the following critical issues:

- Development of design criteria for ACB Lighter Module Structure which can be used to design the lightest possible module/lighter strucutre for the specified service and loads.

- Develop requirements for handling, transportation and stacking of the modules in standard 40 ft container guides.

This first phase study concentrated on the development and evaluation of the various applicable options for efficient and lightweight structural design, outfitting, handling, transportation and stacking of the ACB lighter modules.

The main results of this first phase effort can be summarized as follows:

1. Module Weight

   Despite considerable progress made in developing the preliminary structural design criteria for the ACB lighter modules, this first phase development effort could not achieve the 67,200 lbs maximum allowable weight limit for the lighter module(s). As shown in Tables 3-7.1 and 3-7.2 the total estimated module weights are 87,975 and 75,031 lbs for the center and raked ACB lighter modules respectively. Therefore, the estimated center and raked module weights exceed the 67,200 lbs allowable weight limit by 20,775 lbs and 7,831 lbs respectively.

It must be emphasized that the above module weights include the NFESC estimated weights for the module connector assemblies. The total included connector assembly weights are 24,000 lbs for the center module and 12,000 lbs for the raked module. The design development of the ACB lighter connector assemblies is expected to be completed in the near future by NFESC and others under separate contract. The present weight estimates for the connector are considered to be very preliminary and on the high side.

While the above weight results appear to be highly unfavorable and would tend to eliminate the possibility of utilizing existing standard container cranes, spreads and container trailers for module handling. MR&S believes that a future second phase development effort which would develop and implement the recommended action items for weight reduction would bring the module weights down to the maximum allowable limit of 67,200 lbs. The recommendations for weight reduction are listed in Section 8.0.

2. Module Fittings, Handling, Stacking and Transportation of Modules

The following additional issues were studied during the first phase effort:

- Required fittings for handling, stacking, cargo tie down and mooring were selected. Fitting arrangements, quantities, sizes and capacitates were recommended.
- Requirements for ACB Lighter Module interface with container guides and stacking were developed.
- Module handling and inside terminal transportation scenarios were developed and module interface with standard container handling cranes/spreaders and trailers were investigated.

Assuming that a second phase development effort will be performed and very likely the module handling weight will be reduced to the 67,200 lbs limit, the first phase studies in this report indicate that the 40 ft long by 24 ft wide by 8 ft deep ACB Lighter Modules can be:

- Interfaced with standard 40 ft container guides.
- Stacked up to six high in container holds with a minimum of three adjacent container cells.
- Handled in container terminals with standard container cranes and spreaders.
- Transported by standard container trailers within a terminal.
- Handled (loaded into holds or launched over the side) with the heavy lift cranes of the T-ACS using a four point cargo sling.

1.0 INTRODUCTION

1.1 Objectives

The primary objectives of this Phase I Preliminary Study are:

a. The review of pertinent code and non-code hull design procedures for applicability to the development of a acceptable and practical design criteria for the ACB Lighter structure.

b. Preliminary structural design of the module to verify the feasibility of developing a light but durable hull structure within the 30 long ton handling weight limit set for each lighter module.

c. Selection and arrangement of lighter fittings for handling, stacking, cargo tie-downs mooring etc.

d. Development of intermodal requirements for module stowage, stacking and handling.

e. Development of a preliminary arrangement for the modular ACB lighter.

f. Identification of critical problems for the Advanced Modular Lighterage/Platform Technology Development Program for a potential follow-on Phase II Study.

1.2 Scope

This report documents the findings of the following tasks performed under NFESC Contract N47408-95-C-0211 by M. Rosenblatt & Son, Inc. (MR&S). The tasks performed in this study for NFESC Code ESC31 are part of the ongoing engineering effort of the Advanced Modular Lighterage/Platform Technology Development Program.

Section 1.0, of this report presents a brief overview of the objectives of the Amphibious Cargo Beaching (ACB) Lighter Development Program and this study. Section 2.0, provides a brief overview of the ACB Lighter Concept. Section 3.0 addresses all of the major issues dealt with in this study for ACB Lighter scantling design, hull systems, fittings and mooring. Section 4.0. is a review of intermodal requirements for the ACB module. Section 5.0, is summary of ACB Module Handling. Section 6.0, provides a brief preliminary trim and stability study of the modules and the assembled ACB Lighter. Section 7.0, describes an emerging alternate approach in ACB Lighter architecture which, in lieu of monocoque module construction utilizes 8 ft wide by 8 ft high by 40 ft long ISO container size submodules in the assembly of the 24 ft wide by 40 ft long ACB Lighter Modules. Section 8.0, provide the summary of findings of this Phase I Study and makes recommendations for outstanding critical issues that could be addressed in a Phase II study.

2.0 THE MODULAR ACB LIGHTER CONCEPT

In order to address the inherent limitations of the existing Navy's NL and the Army's Modular Causeway Section (MCS) systems, NFESC developed the concept of a new modular Amphibious Cargo Beaching (ACB) Lighter. The new ACB Lighter is to overcome the many limitations of the existing systems in cargo capacity, freeboard, transportability and operating capability in higher than Sea State 2 weather conditions. The existing Navy lighterage must be transported fully assembled on the top side of its transport ships. Only a limited number of lighters can be carried aboard a few suitable classes of ships.

At the present time, the U.S. Navy is procuring a number of modern Roll-On/Roll-Off type Sealfit ships to enhance its capability to transport military cargo. At the same time, at the final link of the Navy Sealift chain, when cargo is transported ship to shore the existing deficient lighterage systems are used to conduct the crucial Logistics over the Shore (LOTS) operations.

The new ACB Lighterage System is based on the development of standard modules that will be easy to transport and assembled on site. The size of the proposed modules is 24 ft wide by 40 ft long and 8 ft deep. The 40 ft long modules would be capable of being stacked and transported in standard container ship cell guides and in the container holds of special Navy ships such as the Auxiliary Crane Ship (T-ACS). The in hold container guide interface and the stacking of the ACB Lighter Modules is similar to that of the SEA SHED tween deck modules.

In order to be handled by standard container crane spreaders the maximum transportation weight of each module is set at 30 long tons, which is the same as the maximum gross weight of a standard 40 ft long ISO container.

A series of special modules would be developed for different uses. The modules would be raked (bow/stern), center, power and articulated ramp for beaching. Three 40 ft long modules would be connected in the water, to form a standard 24 ft wide by 120 ft long and 8 ft deep ACB Lighter (see Figures 2-1 and 2-2). The lighter modules would be outfitted with all necessary fittings such as rigid connector assemblies, handling, stacking, cargo tie-down and mooring. The large size ACB Lighters would be capable of carrying a high load of military cargo which will primarily consist of 20 ft or 40 ft long ISO size cargo containers, tanks, APCs, trucks an other military vehicles commonly transported by the Navy Sealift Ships. The new lighter would have higher freeboard 3 ft minimum vs. the 1 ft minimum for the existing lighters and could carry out operations in Sea State 3 weather conditions. The ACB Lighter would be used as a modular building block for the construction of a variety of special purpose causeway ferries (single and double wide) and special platforms. The platforms might include Roll-On/Roll-Off platforms, causeway piers, air cushion vehicle landing platforms and air cushioned transport platforms.

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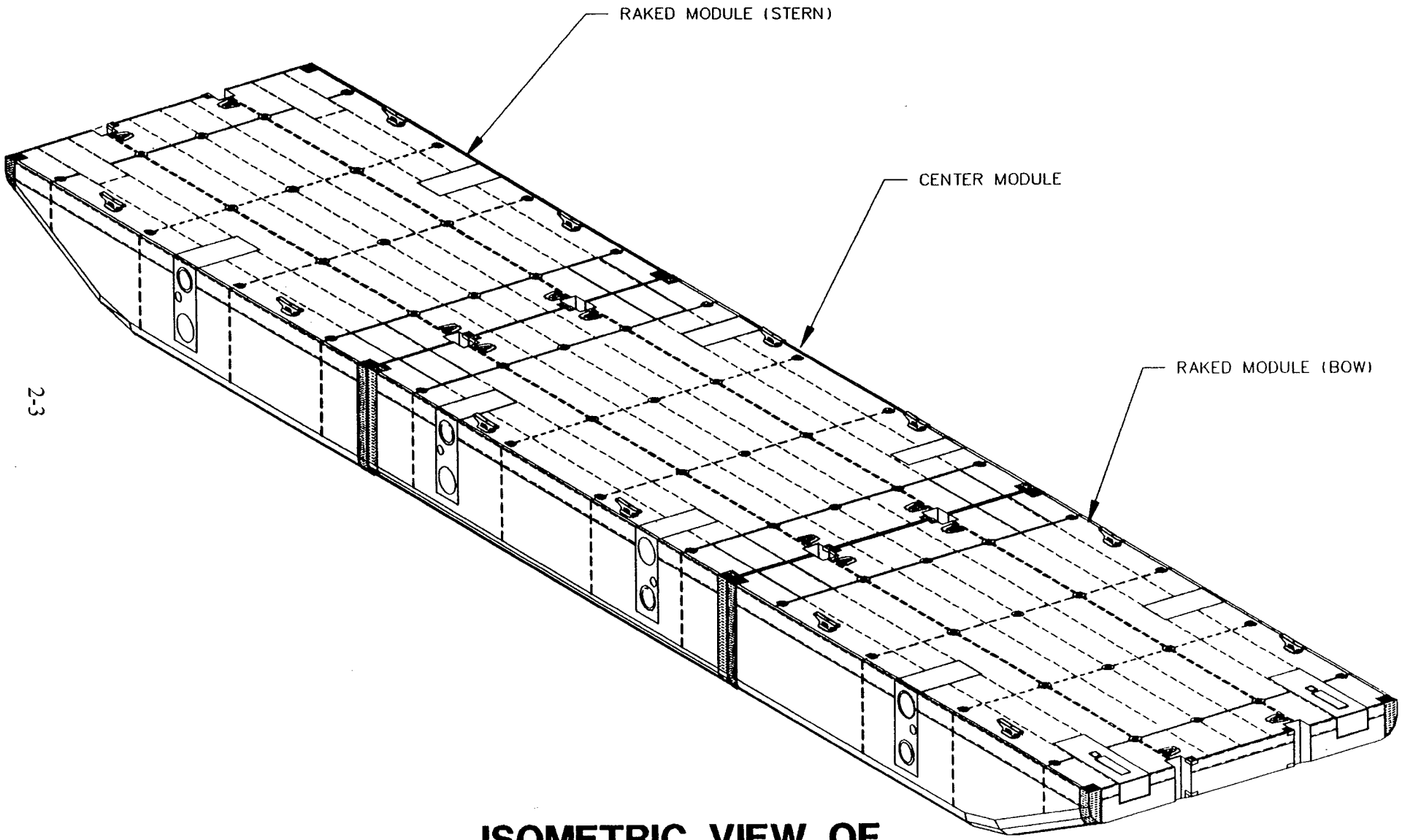
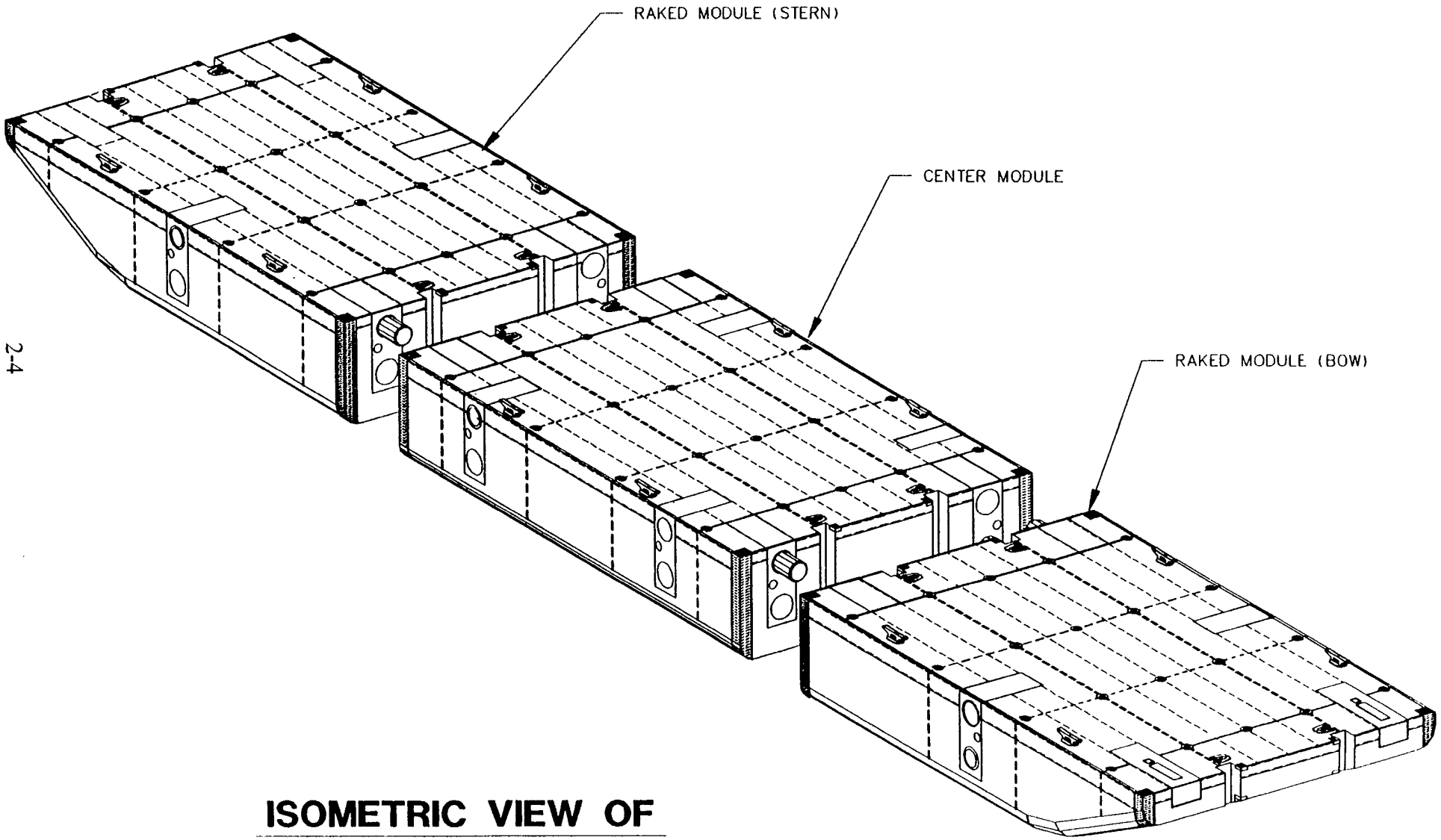


ISOMETRIC VIEW OF
MODULAR ACB-LIGHTER (UNPOWERED)
(24 FT W X 120 FT L X 8 FT D)

FIGURE 2-1



ISOMETRIC VIEW OF
ACB-LIGHTER MODULES LIGNED UP FOR CONNECTION
(24 FT W X 40 FT L X 8 FT D MODULES)

FIGURE 2-2

3.0 DESIGN DEVELOPMENT OF THE MODULAR ACB LIGHTER

3.1 Hull Structure Design

One of the most challenging and important element of the ACB Lighter development program is the weight limited structural design of the lighter modules. Each 24 ft wide by 120 ft long by 8 ft deep ACB Lighter is assembled from three (3) 40 ft long modules. These are the constant depth center module and the raked bow and stern modules.

As a design criteria, the maximum gross weight (structure, attached fittings and connector assemblies) for each module was set at 30 long tons (67,200 lbs) the same as the maximum gross weight of a standard 40 ft long ISO cargo container.

At the 30 long ton gross weight, the ACB Lighter modules can be handled in container terminals with standard container cranes and container spreaders, when loading the modules into container holds similarly to the loading of the SEA SHED modules.

The 67,200 lbs design target for gross weight includes the weight of the following attached fittings:

- Cargo tie-downs
- Stacking and handling
- Mooring/towing
- Module connector assemblies

Therefore the actual weight budget for the structure is much less than the weight limit. Among the listed fitting groups, the weight of the module connector assemblies are the most significant. The design development of the ACB Lighter connectors is expected to be completed in the near future by the Naval Facilities Engineering Service Center (NFESC) and others under separate contract. In the mean time, NFESC provided preliminary dimensions and weights of the connector assemblies for this study. Due to the preliminary nature of the connector weights the weight allowance for the hull structure could not be defined accurately for this study.

Nevertheless, the objective of this preliminary design development study is to find a feasible way to design the lightest possible module structure which is durable and can be reliably operated for the intended service in a Sea State 3 environment while conducting Logistics Over The Shore (LOTS) operations.

3.1.1 Selection of Applicable Design Codes and Procedures

At the outset of this task, NFESC had not yet developed a specific structural design criteria for the ACB Lighter. Therefore, in order to perform the preliminary design of the Lighter module structures, MR&S started out with the review of the "Amphibious Cargo Beaching (ACB) Lighter Feasibility Design" by NFECS Code ESC124 (1994) (Reference 1). In addition, several accepted

design codes for hull structure design which could be used or partially adapted to the development of a preliminary ACB Lighter structural design criteria were selected for consideration. The following codes were selected for hull design:

a. Structural Design Manual for Naval Surface Ships (Reference 2)

b. ABS - Rules for Ocean Barges (Reference 3)

c. ABS - Rules for River Barges (Reference 4)

The deck of the ACB Lighter is subjected to heavy wheel loads by the Rough Terrain Container Handler (RTCH).

The governing wheel load of the RTCH was specified by NFESC as 75 Kip's over 2 ft by 2 ft footprint area. In order to verify the viability of using thinner deck plates than required by the codes, MR&S considered the following deck plating design procedures for comparison and applicability:

- DDS-130-2 "Structural Design and Analysis of Helo Handling Decks" (Navy) (Reference 5)
- Ship Structural Design, by O.F. Hughes, (Reference 6)
- Design of Deck Structures under Wheel Loads, by R.I. Jackson and P.A. Frieze (Reference 7)

The existing designs of the Navy Lighter (NL) and the Army's Modular Causeway Section (MCS) were also reviewed for design criteria.

3.1.2 Preliminary Scantling Design and Scantling Weights

MR&S adopted the following initial approach for the preliminary design of the ACB Lighter modules:

A. All steel plate and shape material to be used in the design shall conform to ASTM A572, grade 50 or equal. A minimum yield stress of 50 ksi will be assumed for the material. This grade of steel provides a good strength to weight ratio and is readily available.

B. Design the longitudinal and transverse members to the code that provides the lightest weight (References 2, 3 and 4).

C. For the lighter longitudinal strength in a seaway, neglect the deck plate contribution to hull section modules. The shell can transfer shears between members so that the deck longitudinal and bottom shell longitudinal members act as a beam with the effective depth of the barge. This beam (hull girder) must meet a longitudinal stress criteria with the most severe longitudinal bending

moment to be developed from hydrostatic calculations. For this preliminary design MR&S used 2,500 Kip-ft bending moment given in Section 5.2.2 of Reference 8.

D. Satisfy minimum criteria for the bottom and side shell with 1/4 inch plating (References 2, 3, and 4).

E. For deck plate design select the procedure from References 5, 6 or 7, which permits the use of the lightest deck plating with an allowable 1/4 inch permanent set under the specified wheel load of the RTCH.

In order to evaluate the various deck plating design procedures for wheel loads, MR&S calculated required deck plate thicknesses and permanent set values for the 75 kip wheel load of the RTCH. The results of the calculation are summarized in Table 3-1. The calculations were performed for three different longitudinal deck stiffener spacings (30 inch, 21 inch and 15 inch).

The 30 inch spacing was used in the NFESC Preliminary Design (Reference 1) and MR&S also used the same spring stiffener spacing for this preliminary design.

The 21 inch spacing was used for the Navy Lighter (NL) design and was selected for comparison purposes as well as the 15 inch spacing. As shown for Case # 4 in Table 3-1, the Jackson & Frieze procedure (Reference 7) would allow the use of 1/4 inch deck plating with 0.245 inch permanent set for the specified wheel load and 30 inch longitudinal deck stiffener spacing. This result agrees with the preliminary design objective set by MR&S for the deck plating design.

Table 3-2 lists strength requirements by the referenced codes and the results of the NFESC Feasibility Design and the MR&S Preliminary Design for comparison purposes.

Table 3-3 compares the existing Navy Lighter (NL) deck scantlings with MR&S calculated deck scantlings for the specified RTCH wheel load. MR&S calculations also indicated that the existing 3/16 inch deck plating would have 7/16 inch permanent set under the RTCH wheel load.

Table 3-4 compares the Army's existing Modular Causeway Sections (MCS) deck plating with MR&S calculated deck scantlings for the specified RTCH wheel load. The calculations indicated that the existing 1/4 inch deck plating of the MCS would have 3/16 inch permanent set under the RTCH wheel load.

In order to find the best approach for designing the lightest module structures for the ACB Lighter, MR&S performed nine different cases of scantling calculations during this phase of the preliminary design. The calculated scantling weight for each case is tabulated and compared to the specified design target weight in summary Table 3-5. The module scantlings for these nine cases, were either designed to the referenced codes or to modified versions of the codes along with selected deck plating design methods as indicated in the table. Modifications were made to reduce the size and weight of selected scantlings such as transverse and longitudinal bulkhead plantings, below code requirements. For each case the reduced scantlings are indicated in the referenced table (see Tables 3-5.1 through 3-5.9). As shown, cases #8 and 9 provided the lightest structural weights for the ACB lighter modules (center and raked). The estimated module

scantling weights are 58,411 lbs for the center module (case #8) and 54,411 lbs for the raked module (case #9).

3.2 Hull Systems and Fittings

3.2.1 Connectors

The Modular ACB Lighter utilizes the following types of connector systems:

a. Rigid end connector assemblies for end to end connection of three basic 40 ft long lighter modules (raked bow, center and raked stern) when assembling them into a 120 ft long ACB Lighter as illustrated in Figure 2-2.

   The center module will have two rigid end connector assemblies installed at each end (Figure 3-17). The raked module will have two rigid end connector assemblies at the 8 ft deep connection end (Figure 3-20).

b. Rigid Side Connector assemblies (similar or identical to the end connectors) for side to side connection of ACB Lighters for the assembly of double-wide causeway ferries or special purpose platforms.

   The center module will have two rigid side connector assemblies at each side. The raked module will have one rigid side connector assembly at each side.

c. Flexor Type Connectors, similar to the existing NL Flexor units for flexible end to end connection of ACB Lighters when assembling causeway ferries from two or more lighters. Two flexor type connector assemblies will be installed at the raked end of each raked bow/stern module (Figure 3-19).

The design development of the ACB Lighter Connector Systems is expected to be completed in the near future by NFESC and others under separate contracts. Therefore at the present time accurate connector weights are not available. For arrangement and weight estimating purposes NFESC Code ESC31 provided the following preliminary information on the rigid and side connector assemblies:

- Assume that each end or side connector assembly module will be 3 ft wide by 5 ft long (planview) and 6 ft high. Preliminary estimated weight for each end or side connector module is 3,000 lbs.

- For the flexor type connectors MR&S allocated 1,000 lbs per connector unit in the weight estimate for the ACB Lighter.

For total allocated connector weights per center or raked module of the ACB Lighter see Tables 3-7.1 and 3-7.2 respectively.

For the general arrangement of the connector assemblies in the ACB Lighter Modules see Figures 3-16 and 3-17 for the center module and Figures 3-18 and 3-19 for the raked module.

3.2.2 ISO Container Fittings

3.2.2.1 Center Module

As shown in Figure 3-16 the 40 ft long center module of the ACB Lighter will be fitted, top and bottom, with standard ISO container fittings. The top container fittings (Figure 3-3) and the bottom container fittings (Figure 3-4) will be integrated in the center module structure in accordance with ISO STD 668. The fittings will be located about the centerline of the module in a pattern identical to that of a 40 ft long STD ISO container.

The installation of the corner fittings in the center module will provide the following capabilities:

1. Handling the module with a standard 40 ft container spreader (Figures 5-1 and 5-2) at shoreside or in the container hold.

2. In container terminal transportation of the module with standard 40 ft container trailers. The modules will be secured by the four (4) twist locks on the trailer frame engaging the bottom container fittings on the module.

3. The container fittings will provide the four (4) top and bottom load bearing points when the modules are stacked on shore or in container guides of a ship's container hold. The fittings can support a maximum of six module high stack in the guides.

3.2.2.2 Raked Module

The 40 ft long raked module of the ACB Lighter will be outfitted with top and bottom standard ISO corner fittings at the full depth end similarly to the center module described in Section 3.2.2.1. The bow/stern end of the raked module is tapered to 2'-6" depth compared to the 8'-0" full depth of the connection end. Thus, the two bottom corner fittings at the raked end will be 5'-6" higher than the bottom corner fittings at the full depth end. Therefore, the stowage foot print of the raked module can not duplicate the footprint of a 40 ft standard ISO container. In order to resolve the transportation and stacking interface problems caused by the depth differential of the raked module ends, MR&S considered the following alternate approaches:

Alternate A

Calls for the installation of a removable adaptor frame at the raked end of the module. The details of the removable adaptor concept is shown in Figure 3-5.

As shown, the adaptor frame would be 5'-6" high and 8'-0" wide. The top of the frame would be secured with twist locks to the lower container corner fittings at the raked end of the module, thus making both ends equal height. To maintain stability under all loading conditions the adaptor frame would also be secured by a hinged brace to two pad-eyes on the module structure as shown. When installed the adaptor frame would line up with the 8'-0" wide by 2'-6" deep guide structure at the raked end of the module and thus would provide a full depth guide surface, for insertion into the cell guides, similarly to the 8'-0" end. The adaptor frame would provide continuity for load support when the modules are stacked in a container hold as shown in Figure 4-2.

The adaptor would allow the raked module to be transported on container trailers within a terminal. The disadvantages of the concept are the estimated 800 lbs added handling weight to the module (see Table 3-7.2) and the fact that the adaptor has to be removed from the module prior to launching over the side. The removed adaptor frames can be folded as shown, for stowage on board the delivery ship.

Alternate B

Calls for the installation of intermediate stacking support pads on the top and bottom side of the modules (raked and center) to provide support points on the modules when the raked modules are stacked in container guides without the removable adaptor frame (Figures 4-2). The advantage of this approach is that the handling weight of the raked module, is reduced by about 800 lbs relative to the Alternate A approach. The disadvantage of Alternate B is the missing twist lock attachment points at the bottom of the raked end, which would prevent the safe loading of the modules on standard container trailers for inside terminal transportation. The combination of Alternate A & B fittings would allow safe module transportation on container trailers. Prior to lifting the raked module into the cargo hold by crane, the adaptor frame would be removed from the raked modules at pier side and only the intermediate stacking pads would be utilized for in hold stocking of the modules as shown in Figure 4-2.

3.2.3 Lift Fittings

In addition to the standard ISO corner fittings for handling the modules with container spreaders as described in Section 3.2.2, a secondary set of four (4) hinged lifting pads (Figure 3-6) are provided on each lighter module as shown in Figures 3-16 and 3-18. The hinged lifting pads will be suitable for sling handling of the modules in similar fashion as shown in Figure 5-3. The hinged lifting pads would be utilized for the following handling scenarios:

a. When damage to the corner fittings prevents handling of the modules using standard container spreaders.

b. During offloading of the modules, from the container holds into the water using the heavy lift crane(s) of the T-ACS.

3.2.4 Cargo Tie Down Fittings

Cargo tie down fittings will be required to secure the cargo on the deck of an ACB Lighter, or aboard causeway ferries assembled from ACB Lighters, when transporting ship to shore cargo during LOTS operations, conducted in Sea State 3 wind and wave conditions.

It is anticipated that the cargo will primarily consist of 20 ft or 40 ft long cargo containers, tanks, APCs, trucks and other military vehicles commonly transported by the Navy's Sealift Ships. The deck fittings selected by MR&S are universally for all anticipated cargo types and are identical types as the cargo tie-down fitting selected for the new Navy Sealift Ships under construction. However, tentatively, fittings with 35,000 lbs breaking strength have been selected instead of the 70,000 lbs rating for the fittings on the Sealift Ships. This reduction in strength is justified by the fact that the cargo tie down fittings aboard the Sealift ships must withstand loads associated

with open ocean transit conditions of see state 8 (sea storm condition) while the ACB Lighter will typically operate in conditions not exceeding sea state 3. The smaller and lighter fittings also reduce the weight of the modules.

The selection of the 35,000 lbs capacity fittings must be verified by a more detailed cargo tie down study and related load calculations as suggested in Section 8.2 for a possible Phase II study.

The following tie down options were considered:

Option A

Flush tie down fittings, shown in Figures 3-7 and 3-8, are recessed into the deck of the barge. Flush fittings provide for a smooth deck surface thus do not obstruct vehicular or personnel traffic. However, the flush fittings will collect water within the recesses and pose a corrosion maintenance problem and add more weight to the modules, see Table 3-6. Modules equipped with flush tie down fittings would have 8'-1" stacking height as shown in Figure 3-5.

Option B

Raised fittings, shown in Figures 3-9 and 3-10, are installed on the top of the deck do not collect water but will pose a hazard to personnel working on the deck and present a minor obstruction to vehicular traffic. Added benefits are a small reduction of weight, see Table 3-6, and ease of installation with attendant cost reduction. Modules equipped with raised tie down fittings would have 8'-3" stacking height as shown in Figure 3-5.

For each option, the port and starboard deck edges of each module will be fitted with D-Rings and the inboard area of the deck will be fitted with Cloverleaf Sockets, thereby providing the required universality and flexibility in spotting cargo.

The tie down deck fittings are located for easy integration with the module structure to minimize added weight needed for structural reinforcement. The D-Rings are aligned with the transverse bulkheads at the hull sides, port and starboard. The Cloverleaf Sockets are coincident with the intersection of the transverse bulkheads and the longitudinal bulkheads, port and starboard, or the C.L. deck girder as shown in Figures 3-17 and 3-19.

Standard tie down lashings are available in adjustable length, wire rope or chain types with a variety of end connections to suit the cargo units and the deck fittings. The breaking strength of the lashings will match the strength of the deck fittings. The exact mix of lashing assemblies to be carried with the ACB Lighter remains to be determined. A typical example of a suitable tie down assembly is shown in Figure 3-11.

3.2.5 Mooring/Towing and Anchoring

3.2.5.1 Mooring Fittings

Deck fittings will be required for mooring and waterborne handling of modules and lighters and

lighter configurations of platforms and causeways. In order to reduce the use of multiple mooring fittings (bitts, chocks, cleats, etc), tools and hardware and to reduce weight, a universal type of fitting was investigated to suit the multiple waterborne handling and mooring requirements of modules and lighters.

The conclusion of the investigation resulted in the selection of a kevel cleat as the type of fitting to suit the requirements. The kevel cleat is a combination of a cleat and chock and is suitable for handling, fairleading and securing synthetic ropes during mooring and waterborne operations and for securing wire rope from winches when moored and positioned alongside ships.

The kevel cleats can not remain in place on the modules deck when the modules are stacked ashore or being transported in container cells. To meet this requirement, two (2) configurations were considered, which are a removable type and a hinged in place type for recessed stowage. Each configuration meets the "clean deck" requirement for storage or transit.

The bolted removable kevel cleats (see Figure 3-12) will be stowed onboard the module transport ship and installed, as required, prior to off loading the modules. This will result in a reduction of module weight during transit as indicated in Table 3-6. This configuration will require additional logistic support, including labor for handling and installation at the site, also stowage provisions and area must be provided by the module transporting ship.

The hinged kevel cleat will be housed within the module (see Figure 3-13), thereby reducing manpower support, but the module weight will be increased as indicated in Table 3-6 as well as the maintenance requirements.

At the present time, it is estimated that four (4) kevel cleats, two (2) each side, will be required for each module, with each kevel cleat having an estimate weight of one hundred (100) pounds, as indicated in Table 3-6. The actual weight, along with the size and strength of the kevel cleat will be determined by the mooring and towing lines size, strength and construction, which will be defined in Phase II.

3.2.5.2 Mooring Lines

U.S. Navy ships are presently using polyester and arimad mooring lines, with most of the newer ships being outfitted with arimad lines by the ship builder in accordance with ship specifications. A few Navy ships which were backfitted with arimad lines, have reverted back to using polyester lines, based on their own preferences. Each type of line has its own advantages and disadvantages, which must be addressed when determining the selection, sizing and construction of lighter mooring lines in Phase II.

Although the forces acting on a moored lighter and the angles of the mooring lines cannot be accurately predicted, a tentative mooring line arrangement can be developed and refined during the design analysis. NAVFAC and NAVSEA each have design approaches for analyzing mooring arrangements, but their analysis will have to include wave forces, as waves will have a significant effect on a lighter moored to a ship anchored offshore.

3.2.5.3 Mooring and Positioning Modules Concept for Alongside Assembly

The modules will be assembled in the water into lighters, causeway and platforms. In the interest of safety, the modules should be assembled at the leeward side of the heavy lift T-ACS crane ship to minimize the effects of wind and wave on the operation. Mooring and fendering configurations can be developed, alongside the T-ACS ship, to provide position control and damping of the motion of modules in the water, see Figure 3-14 for lighter assembly. The T-ACS ship's conventional mooring system can be used to control and position the modules and their various assembled forms, however, due to the number of modules involved, additional T-ACS mooring equipment may be required. The type of mooring equipment and their arrangement, to assist in module assembly alongside, will be dependant on the module connection fitting requirements which are being developed by others.

3.2.5.4 Anchoring

At present, both the U.S. Army and the U.S. Navy have similar procedures for anchoring lighters offshore. That is, the bitter end of the anchor cable securing chain is connected to the chain plate, the tending craft casts off to a point perpendicular to the causeway and places the anchor. The exact placing of anchors is dependant on the prevailing environmental conditions. While the U.S. Navy utilizes an array of lightweight anchors ranging between five hundred (500) to three thousand (3,000) pounds, the U.S. Army uses two thousand (2,000) pound NAVMOOR anchors. Anchor size, tandem anchors and quantity of anchor mooring legs are dependant on environmental conditions and quantity of lighters in the causeway make-up.

Anchor efficiency is measured by the ratio of the holding power of an anchor to its weight. To obtain maximum holding power, the anchor must dig into the bottom. To accomplish this an anchor must be dragged to have the flukes dig in and set the anchor.

Phase II should explore methods of setting the offshore anchors by having the tending craft positioning the offshore anchor while having the setting of the anchor accomplished by hauling in on the anchor cable at the lighter. After the scope is set the anchor cable is stopped off from the causeway lighter connecting point.

The anchoring operation at the lighter can be accomplished with chain stoppers, chain haulers or utilizing the SLWT and/or its winch.

3.3 Modular ACB Lighter Assembly

The general arrangement and key dimensions of the Modular ACB Lighter, developed by MR&S in this preliminary study is shown in Figure 3-15. The estimated lightship weight of the fully outfitted ACB Lighter is given in Table 3-7.

The 24 ft wide by 120 ft long by 8 ft deep ACB Lighter is assembled from the following 40 ft long basic modules:

a. One (1) Center Module Assembly. The general arrangement of the center module is shown in Figures 3-16 and 3-17. The estimated lightship weight of a fully

outfitted center module is given in Table 3-7.1.

b. Two (2) Raked Module Assemblies (Bow and Stern). The general arrangement of a typical raked module is shown in Figures 3-18, 3-19 and 3-20. The estimated lightship weight of a fully outfitted raked module is given in Table 3-7.2.

TABLE 3-1

ACB LIGHTER CENTER MODULE

(24FT W X 40FT L X 8FT D)
COMPARISON OF REQUIRED DECK PLATING THICKNESSES
DESIGNED FOR 75 KIPS WHEEL LOAD OVER
2 FT SQUARE FOOTPRINT OF THE RTCH (*)
(DECK MATERIAL YIELD: 50 KSI)
LONGITUDINAL DECK STRINGER SPACINGS: 30", 21" AND 15"

CASE #	DK PL DESIGN IN ACCORDANCE WITH		REQUIRED DK PL THK		
			LONGITUDINAL DECK STRINGER SPACING		
			30"	21"	15"
1	DDS130-2 (Navy)	Ref 5	0.495"	0.3722"	0.2463"
2	ABS Rules for Ocean Barges, 91	Ref 3	0.5855"	0.4504"	0.3153"
3	Ship Structural Design by Owen Hughes	Ref 6	0.3402" Permanent Set = 0.246"	0.2858" Permanent Set = 0.2715"	0.2552" Permanent Set = 0.1225"
4	Design of Dk Struct Under Wheel Loads By Jackson & Frieze	Ref 7	0.2552" Permanent Set = 0.245"	0.2143" Permanent Set = 0.1715"	0.1914" Permanent Set = 0.1225"

Note:

(*) Rough Terrain Container Handler

TABLE 3-2

COMPARISON OF BEAM SM_{REQD} PLTH t_{REQD} & AXIAL A_{REQD}

ACB LIGHTER STRUCTURE	REF 1	REF 2	REF 3	REF 4	MR&S PRELIMINARY
	NFESC PRELIMINARY (AISC CODE)	NAVY SURFACE SHIP	ABS OCEAN BARGE	ABS RIVER BARGE	ABS RIVE BARGE MODIFIED**
1. Bott PL, t_r (in)	0.25	0.2121	0.276	0.25	0.25
2. Bott Long'l, SM_r (in^3)	43.56	10.3	7.92	6.37	6.37
3. Side PL, t_r (in)	0.25	0.1588	0.25	0.25	0.25
4. Side Long'l, SM_r (in^3)	7.1	4.55	5.9	5.1	5.1
5. Deck PL, t_r (in)	0.25	0.4915	0.59	0.65	0.25
6. Deck Long'l, SM_r (in^3)	68.18	52.69	33.48	33.4	33.4
7. Bott Transv, SM_r (in^3)	43.56	22.63	21.6	14.4	14.4
8. Side Transv, SM_r (in^3)	20.55	13.94	*8.06	*7.56	*7.56
9. Deck Transv, SM_r (in^3)	43.56	43.51	*60.00	*60.00	*60.0
10. Truss Diagonal, A_r (in^2)	2.96	2.21	2.50	2.5	2.5
11. Stanchion, A_r (in^2)	4.71	2.07	4.18	4.18	4.18
12. End PL, t_r (in)	0.25	0.1984	0.25	0.25	0.25
13. End Stiff, SM_r (in^3)	7.1	3.48	7.9	7.9	7.99
14. Wt Bhd Plt (in)	.1875	0.25	0.25	0.1875	0.1875

NOTES:

* Axial load or shear will govern these members.
** Deck plating design by Jackson & Frieze (Ref 7).

TABLE 3-3

NAVY LIGHTER (NL)

PONTOON ASSEMBLY & DETAILS (P-1)
DWG #80091-6138922, REV B
COMPARISON OF:
EXISTING DECK SCANTLINGS & MR&S CALCULATED SCANTLINGS (*)
Matl: MS

STRUCTURE	EXISTING DECK SCANTLINGS	CALCULATED SCANTLINGS(*)
Deck Pltg 21" x 60"	Plating, t = 3/16"	(Jackson & Frieze) (Ref 7) Plating, t = 1/4" w/Permanent Set = 3/16"
DK Long'l Spcg = 21" Span = 39"	Angle Made From: 8 1/2" W x 3/16" PL Assume 5 x 3 1/2 x 3/16 L SM = 5.8 in^3 A_s = 0.94 in^2	(ABS River Barge) (Ref 4) 6 x 4 x 5/8 L SM = 16.4 M^3 A_s = 3.75 M^2

TABLE 3-4

COMPARISON TABLE

ARMY'S MODULAR CAUSEWAY SECTION (MCS)
ISO LOG SERIES C45
MODEL 402 MC ML MR
COMPARISON OF:
EXISTING DECK SCANTLINGS & MR&S CALCULATED SCANTLINGS(*)

STRUCTURE	EXISTING DECK SCANTLINGS	CALCULATED SCANTLINGS(*)
Deck Pltg Panel 13 1/2" x 18"	Plating, t = 1/4"	(Owen Hughes) (Ref 6) Plating, t = 1/4" w/Permanent Set = 3/16"
Deck Long'l Spcg = 17" Span = 60"	(2) 3 x 2 x 3/16 L SM = 3.07 in^3 A_s = 1.13 in^2	(ABS River Barge) (Ref 4) (2) 6 x 3 1/2 x 1/2 L SM = 24.4 in^3 A_s = 6.0 in^2
Dk Stiff Transv Spcg = 17" Span = 17 1/2"	3 x 2 x 3/16 L SM = 1.53 in^3 A_s = 0.56 in^2	(ABS River Barge) (Ref 4) 3 1/2 x 2 1/2 x 3/8 L SM = 3.7 in^3 A_s = 1.31 in^2

Note - (*) 75 Kip Wheel Load Over 2' x 2' Footprint Area (RTCH).

TABLE 3-5
SUMMARY OF ACB LIGHTER MODULE ESTIMATED SCANTLING WEIGHTS

CASE #	SEE TABLE	MODULE	SEE FIGURE	DESIGN CODE OR METHOD				A ESTIMATED MODULE SCANTLING WT (LBS)	B DESIGN TARGET WT (LBS)	C DELTA WT (A-B) (LBS)	D DELTA WT IN % OF B
				MODULE SCANTLING		DECK PLATING FOR RATCH WHEEL LOAD					
1	3-5.1	CENTER	---	REF 2	US NAVY REQUIREMENTS	REF 5	DDS 130-2 (NAVY)	73982	67200	(+) 6782	(+) 10.09
2	3-5.2	CENTER	---	REF 2	US NAVY REQUIREMENTS (MODIFIED)	REF 7	JACKSON & FRIEZE	62885	67200	(-) 4315	(-) 6.42
3	3-5.3	CENTER	---	REF 3	ABS OCEAN BARGE REQUIREMENTS (INCLUDES DK DESIGN FOR WHEEL LOADS)			76146	67200	(+) 8946	(+) 13.31
4	3-5.4	CENTER	---	REF 3	ABS OCEAN BARGE REQ (MODIFIED)	REF 7	JACKSON & FRIEZE	60024	67200	(-) 7176	(-) 10.68
5	3-5.5	CENTER	---	REF 4	ABS RIVER BARGE RULES (INCLUDES DK DESIGN FOR WHEEL LOADS)			75808	67200	(+) 8608	(+) 12.81
6	3-5.6	CENTER	---	REF 4	ABS RIVER BARGE RULES (MODIFIED)	REF 7	JACKSON & FRIEZE	59347	67200	(-) 7853	(-) 11.68
7	3-5.7	CENTER	---	REF 4	ABS RIVER BARGE RULES (MODIFIED)	REF 7	JACKSON & FRIEZE	63445	67200	(-) 3755	(-) 5.58
8	3-5.8	CENTER	3-1	REF 4	ABS RIVER BARGE RULES (MODIFIED)	REF 7	JACKSON & FRIEZE	58411	67200	(-) 8789	(-) 13.07
9	3-5.9	RAKED	3-2	REF 4	ABS RIVER BARGE RULES (MODIFIED)	REF 7	JACKSON & FRIEZE	54811	67200	(-) 12389	(-) 18.44

NOTES

1. MODULE SCANTLING FOR CASES 1, 3 AND 5 WERE DESIGNED TO THE SPECIFIED CODES
2. MODULE SCANTLINGS FOR ALL OTHER CASES WERE DESIGNED TO MODIFIED CODES, MODIFICATIONS WERE MADE TO REDUCE SCANTLING WEIGHTS. IN GENERAL DECK, LONGITUDINAL AND TRANSVERSE FRAME SPACINGS WERE 30 INCHES AND 10 FEET RESPECTIVELY, EXCEPT FOR CASES 6 AND 7, WHERE SPACING WERE CHANGED TO ASCERTAIN SPACING INFLUENCE AN SCANTLING WEIGHTS. THE SPECIFIC MODIFICATIONS FOR EACH CASE ARE DEFINED IN THE REFERENCED TABLE(S).
3. MATERIAL FOR ALL SCANTLINGS WERE ASSUMED TO HAVE 50 KSI YIELD.
4. DECK PLATING FOR ALL CASES WERE DESIGNED FOR 75 KIPS WHEEL LOAD OF THE ROUGH TERRAIN CONTAINER HANDLER (RTCH) DISTRIBUTED OVER A 2' X 2' FOOT PRINT.
5. a. VALUES INDICATED WITH (+) ARE OVER THE DESIGN TARGET WT (B)
   b. VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)
6. CASES 8 & 9 ARE THE CANDIDATE STRUCTURAL DESIGNS FOR THIS PRELIMINARY DESIGN STUDY.

TABLE 3-5.1

ACB LIGHTER CENTER MODULE

(24FT W X 40FT L X 8 FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
a. U.S. NAVY REQUIREMENTS (REFERENCE 2)
FOR ALL SCANTLINGS
b. U.S. NAVY DDS 130-2 FOR DECK PL(*) (REFERENCE 5)

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	Deck Plate	0.492	24	40		40.8	19271
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792
2	End Plate 1/4"	0.25	8	24		40.8	3917
11	Deck Long'l 16 x 7 x 36# I/T plus 2				40	26.45	11638
8	Side Long'l WT 4 X 6#				40	6	1920
7	Bottom Long'l WT 6 X 4 X 11# minus 2				40	11	3080
14	End Stiff WT 4 X 4 X 5#				6	10.4	874
4	End Stiff 16 X 7 X 36# I/T				5	26.45	529
4	Deck Transv 14 X 6.75 X34# I/T				24	24.3	2333
12	Side Transv 10 x 4 X 15# I/T				5	11.55	693
4	Btm Transv 10 X 5.75 X 22# I/T				24	14.79	1420
2	Long'l Edge Capping 16 x 5.5 x 26# I/T				40	19.4	1552
2	Transv Edge Capping 10 x 4 x 19#				24	8.93	429
8	Stanchions 6 X 6 X 15#				5	15	600
16	Diagonals 6X 6 X 15#				12	15	2880
2	WT Long'l Bulkhead Plates 1/4"	0.25	5	40		40.8	4080
2	WT Transv Bulkhead Plates 1/4"	0.25	5	24		40.8	2448

A.	TOTAL ESTIMATED SCANTLING WT:		73982
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B):	(+)	6782 (**)
D.	DELTA WT IN % OF B:	(+)	10.09 (**)

NOTES:
(*) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (+) ARE OVER THE DESIGN TARGET WT (B)

TABLE 3-5.2
ACB LIGHTER CENTER MODULE
(24FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
a. U.S. NAVY REQUIREMENTS (REFERENCE 2)
MODIFIED AS INDICATED
b. DECK PLATING (*) BY JACKSON & FRIEZE (REFERENCE 7)

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792
2	End Plate 1/4"	0.25	8	24		40.8	3917
11	Deck Long'l 16 x 7 x 36# I/T plus 2				40	26.45	11638
8	Side Long'l WT 4 X 6#				40	6	1920
7	Bottom Long'l WT 6 X 4 X 11# minus 2				40	11	3080
14	End Stiff WT 4 X 4 X 5#				6	10.4	874
4	End Stiff 16 X 7 X 36# I/T				5	26.45	529
4	Deck Transv 14 X 6.75 X34# I/T				24	24.3	2333
12	Side Transv 10 x 4 X 15# I/T				5	11.55	693
4	Btm Transv 10 X 5.75 X 22# I/T				24	14.79	1420
2	Long'l Edge Capping 16 x 5.5 x 26# I/T				40	19.4	1552
2	Transv Edge Capping 10 x 4 x 19#				24	8.93	429
8	Stanchions 6 X 6 X 15#				5	15	600
16	Diagonals 6X 6 X 15#				12	15	2880
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	40		40.8	3068
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	24		40.8	1841

A.	TOTAL ESTIMATED SCANTLING WT:		62885
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B):	(-)	4315 (**)
D.	DELTA WT IN % OF B:	(-)	6.42 (**)

NOTES
(*) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)

TABLE 3-5.3

ACB LIGHTER CENTER MODULE

(24FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS OCEAN BARGE REQUIREMENTS (REFERENCE 3)
FOR ALL SCANTLINGS(*)

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	Deck Plate	0.59	24	40		40.8	23109
2	Side Plate	0.25	8	40		40.8	6528
1	Bottom Plate	0.276	24	40		40.8	10810
2	End Plate	0.25	8	24		40.8	3917
11	Deck Long'l 16 x 5.5 x 26# I/T plus 2				40	19.4	8536
6	Side Long'l 5 x 3 x 5/16				40	8.2	1968
7	Bottom Long'l 6 x 3 1/2 x 5/16 minus 2				40	9.8	2744
14	End Stiff 5 x 3 1/2 x 3/8				6	10.4	874
4	End Stiff 16 x 5.5 x 26# I/T				5	19.4	388
4	Deck Transv 16 x 5.5 x 31# I/T				24	22.67	2176
8	Side Transv 10 x 4 x 19# I/T				5	8.93	357
4	Btm Transv 16 x 5.5 x 26# I/T				24	19.4	1862
2	Long'l Edge Capping 16 x 5.5 x 26# I/T				40	26	2080
2	Transv Edge Capping 10 x 4 x 19# I/T				24	19	912
8	Stanchions 10 x 4 x 19# I				5	19	760
16	Diagonals 8 x 15 x 10# I				12	10	1920
2	WT Long'l Bulkhead Plates 1/4"	0.25	5	44.142		40.8	4502
2	WT Transv Bulkhead Plates 1/4"	0.25	5	26.485		40.8	2701

A.	TOTAL ESTIMTED SCANTLING WT:		76146
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B):	(+)	8946 (**)
D.	DELTA WT IN % OF B:	(+)	13.31 (**)

NOTES:
(*) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (+) ARE OVER THE DESIGN TARGET (B)

TABLE 3-5.4
ACB LIGHTER CENTER MODULE
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS OCEAN BARGE RULES (*) (REFERENCE 3) MODIFIED AS INDICATED

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	***Bottom Plate 1/4"***	0.25	24	40		40.8	9792
2	*End Plate 1/4"*	0.25	8	24		40.8	3917
11	*Deck Long'l 16 x 5.5 x 26# I/T plus 2*				40	19.4	8536
6	*Side Long'l 5 x 3 x 5/16*				40	8.2	1968
7	*Bottom Long'l 6 x 3 1/2 x 5/16 minus 2*				40	9.8	2744
14	*End Stiff 5 x 3 1/2 x 3/8*				6	10.4	874
4	*End Stiff 16 x 5.5 x 26# I/T*				5	19.4	388
4	*Deck Transv 16 x 5.5 x 31# I/T*				24	22.67	2176
8	*Side Transv 10 x 4 x 19# I/T*				5	8.93	357
4	*Btm Transv 16 x 5.5 x 26# I/T*				24	19.4	1862
2	*Long'l Edge Capping 16 x 5.5 x 26# I/T*				40	26	2080
2	*Transv Edge Capping 10 x 4 x 19# I/T*				24	19	912
8	*Stanchions 10 x 4 x 19# I*				5	19	760
16	*Diagonals 8 x 15 x 10# I*				12	10	1920
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	44.142		40.8	3386
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	26.485		40.8	2032

A.	TOTAL ESTIMATED SCANTLING WT:		60024
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT (A-B):	(-)	7176 (**)
D.	DELTA WT IN % OF B:	(-)	10.68 (**)

NOTES:
(*) GOVERNING DESIGN DECK LOAD - 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)

TABLE 3-5.5
ACB LIGHTER CENTER MODULE
(24FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES (REFERENCE 4)
FOR ALL SCANTLINGS(*)

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	Deck Plate	0.65	24	40		40.8	25459
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792
2	End Plate 1/4"	0.25	8	25		40.8	4080
11	Deck Long'l 16 x 5.5 x 26# I/T plus 2				40	19.4	8536
8	Side Long'l 5 x 3 1/2 x 1/4				40	7	2240
7	Bottom Long'l 5 x 3 1/2 x 5/16 minus 2				40	8.7	2436
14	End Stiff 5 x 3 1/2 x 3/8				6	10.4	874
4	End Stiff 16 x 5.5 x 26# I/T				5	19.4	388
4	Deck Transv 16 x 5.5 x 31# I/T				24	22.67	2176
12	Side Transv 10 x 4 x 19# I/T				5	8.93	536
4	Btm Transv 16 x 5.5 x 26# I/T				24	19.4	1862
2	Long'l Edge Capping 16 x 5.5 x 26# I/T				40	19.4	1552
2	Transv Edge Capping 10 x 4 x 19#				24	8.93	429
8	Stanchions 10 x 4 x 19# I				5	19	760
16	Diagonals				12	8.5	1632
2	WT Long'l Bulkhead Plates 1/4	0.25	5	40		40.8	4080
2	WT Transv Bulkhead Plates 1/4	0.25	5	24		40.8	2448

A.	TOTAL ESTIMATED SCANTLING WT:		75808
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B):	(+)	8608 (**)
D.	DELTA WT IN % OF B:	(+)	12.81 (**)

NOTES:
(*) GOVERNING DESIGN DECK WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (+) ARE OVER THE DESIGN TARGET WT (B)

TABLE 3-5.6
ACB LIGHTER CENTER MODULE
(24FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES(*) (REFERENCE 4) MODIFIED AS INDICATED
Deck longitudinal spacing 15" transverse frame spacing 10FT

MODIFIED REDUCED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792
2	End Plate 1/4"	0.25	8	24		40.8	3917
18	Deck Long'l 12 x 4 x 16.5# I/T plus 2				40	13.11	9439
8	Side Long'l 5 x 3 1/2 x 1/4				40	7	2240
7	Bottom Long'l 5 x 3 1/2 x 5/16 minus 2				40	8.7	2436
14	End Stiff 5 x 3 1/2 x 3/8				6	10.4	874
4	End Stiff 16 x 5.5 x 26# I/T				5	19.4	388
4	Deck Transv 16 x 7 x 36# I/T				24	36	3456
12	Side Transv 10 x 4 x 19# I/T				5	8.93	536
4	Btm Transv 16 x 5.5 x 26# I/T				24	19.4	1862
2	Long'l Edge Capping 16 x 5.5 x 26# I/T				40	19.4	1552
2	Transv Edge Capping 10 x 4 x 19#				24	8.93	429
8	Stanchions 10 x 4 x 19# I				5	19	760
16	Diagonals 6 x 4 x 12 # I				12	8.5	1632
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	37.37		40.8	2866
2	***Transv Bhd out iwo stan & Diag***	-0.188	0.83	68		40.8	-866
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	22.34		40.8	1714

A.	TOTAL ESTIMATED SCANTLING WT:		59347
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B):	(-)	7853 (**)
D.	DELTA WT IN % OF B:	(-)	11.68 (**)

NOTES:
(*) GOVERNING DESIGN DECK WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)

TABLE 3-5.7
ACB LIGHTER CENTER MODULE
(24FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES (*) (REFERENCE 4) MODIFIED AS INDICATED
DECK LONGITUDINAL SPACING : 30" - TRANSVERSE FRAME SPACING: 5FT

REDUCED MODIFIEDSCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792
2	Side Plate 1/4"	0.25	8	40		40.8	6528
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792
2	End Plate 1/4"	0.25	8	24		40.8	3917
11	Deck Long'l 14 x 6.75 x 30# I/T plus 2				40	21.69	9544
8	Side Long'l 3 x 2 x 3/16				40	3.07	982
7	Bottom Long'l 3 x 2 x 3/16 minus 2				40	8.7	2436
14	End Stiff 5 x 3 1/2 x 3/8				6	10.4	874
4	End Stiff 14 x 6.75 x 30# I/T				5	21.69	434
7	Deck Transv 14 x 6.75 x 30# I/T				24	21.69	3644
18	Side Transv 10 x 4 x 19# I/T				5	8.93	804
7	Btm Transv 14 x 6.75 x 30# I/T				24	21.69	3644
2	Long'l Edge Capping 14 x 6.75 x 30# I/T				40	21.69	1735
2	Transv Edge Capping 10 x 4 x 19#				24	8.93	429
14	Stanchions 10 x 4 x 19# I				5	19	1330
26	Diagonals 6 x 4 x 12# I				12	8.5	2652
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	40		40.8	3068
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	24		40.8	1841

A.	TOTAL ESTIMATED SCANTLING WT:		63445
B.	DESIGN TARGET WEIGHT (30LT):		67200
C.	DELTA WT = (A-B)	(-)	3755 (**)
D.	DELTA WT IN % OF B:	(-)	5.58 (**)

NOTES:
(*) GOVERNING DESIGN DECK LOAD - 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)

TABLE 3-5.8
ACB LIGHTER CENTER MODULE
(20FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES (*) (REFERENCE 4) MODIFIED AS INDICATED

DECK LONGITUDINAL SPACING: 30" - TRANSVERSE FRAMING: 10 FT

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.	From Bottom	From Transv CL	From Longl CL
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)	VCG (FT)	LCG (FT)	TCG (FT)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792	8	0	0
2	Side Plate 1/4"	0.25	8	40		40.8	6528	4	0	0
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792	0	0	0
2	End Plate 1/4"	0.25	8	24		40.8	3917	4	0	0
11	Deck Long'l 16 x 5.5 x 26# I/T plus 2				40	19.4	8536	8	0	0
8	Side Long'l 5 x 3 1/2 x 1/4				40	7	2240	4	0	0
7	Bottom Long'l 5 x 3 1/2 x 5/16 minus 2				40	8.7	2436	0	0	0
18	End Stiff 5 x 3 1/2 x 3/8				6	10.4	1123	4	0	0
4	End Stiff 16 x 5.5 x 26# I/T				5	19.4	388	4	0	0
4	Deck Transv 16 x 7 x 36# I/T				24	26.45	2539	8	0	0
12	Side Transv 10 x 4 x 19# I/T				5	8.93	536	4	0	0
4	Btm Transv 16 x 5.5 x 26# I/T				24	19.4	1862	0	0	0
2	Longl Edge Capping 16 x 5.5 x 26# I/C				40	19.4	1552	8	0	0
2	Transv Edge Capping 10 x 4 x 19#C				24	8.93	429	8	0	0
8	Stanchions 10 x 4 x 19# I				5	19	760	4	0	0
16	Diagonals 6 X 4 X 12 # I				12	8.5	1632	4	0	0
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	40		40.8	3068	4	0	0
2	***No Pit iwo stan & Diag of transv bhd***	-0.188	0.83	44		40.8	-560	4	0	0
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	24		40.8	1841	4	0	0

A.	TOTAL ESTIMATED SCANTLING WT:		58411	4.60	0.00	0.00
B.	DESIGN TARGET WEIGHT (30LT):		67200			
C.	DELTA WT = (A-B):	(-)	8789 (**)			
D.	DELTA WT IN % OF B:	(-)	13.07 (**)			

NOTES:

(*) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)
FOR SCANTLING ARRANGEMENT SEE FIGURE #3-1

TABLE 3-5.9
ACB LIGHTER "RAKED" MODULE STRUCTURE
(24FT W X 40FT LG X 8 FD TAPERED TO 2.5FT @ RAKED END)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES (*) (REFERENCE 4) MODIFIED AS INDICATED
Deck longitudinal spacing 30" - Transverse spacing 10FT

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.	From Bottom	From 8' Depth End	From CL
		t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)	VCG (FT)	LCG (FT)	TCG (FT)
1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792	8	20	0
2	Side Plate 1/4"	0.25	8	26.33		40.8	4297	4	13.4	0
2	Side Plate 1/4"	0.25	5.25	13.67		40.8	1464	5.33	33.4	0
1	Bottom Plate 1/4"	0.25	24	40		40.8	9792	0	20	0
1	End Plate 1/4"	0.25	8	24		40.8	1958	4	0	0
1	End Plate 1/4"	0.25	2.5	24		40.8	612	6.75	40	0
11	Deck Long'l 16 x 5.5 x 26# I/T plus 2				40	19.4	8536	8	20	0
8	Side Long'l 5 x 3 1/2 x 1/4 L				26.33	7	1474	4	13.4	0
8	Side Long'l 5 x 3-1/2 x 1/4 L				8.09	7	453	5.33	33.4	0
7	Bottom Long'l 5 x 3 1/2 x 5/16 minus 2				40	8.7	2436	0	20	0
9	End Stiff 5 x 3 1/2 x 3/8 L				6	10.4	562	4	0	0
9	End Stiff 5 x 3-1/2 x 3/8 L				2.5	10.4	234	6.75	40	0
2	End Stiff 16 x 5.5 x 26# I/T				5	19.4	194	4	0	0
2	End Stiff 16 x 5.5 x 26# I/T				2.5	19.4	97	6.75	40	0
4	Deck Transv 16 x 7 x 36# I/T				24	26.45	2539	8	20	0
8	Side Transv 10 x 4 x 19# I/T				5	8.93	357	4	11.25	0
4	Side Transv 10 x 4 x 19# I/T				3.25	8.93	116	6.75	35	0
4	Btm Transv 16 x 5.5 x 26# I/T				24	19.4	1862	0	20	0
2	Long'l Edge Capping 16 x 5.5 x 26# I/C				40	19.4	1552	8	20	0
2	Transv Edge Capping 10 x 4 x 19#C				24	8.93	429	8	20	0
6	Stanchions 10 x 4 x 19# I				5	19	570	4	15	0
2	Stanchions 10 x 4 x 19# I				2.5	19	95	6.75	35	0
12	Diagonals 6 X 4 X 12 # I				12	8.5	1224	8	15	0
4	Diagonals 6 x 4 x 12# I				10	8.5	340	6.75	35	0
2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5	26.33		40.8	2020	4	13.4	0
2	***WT Long'l BHD Plates 3/16"***	0.188	2.5	13.67		40.8	524	6.75	33.4	0
2	***No Plt lwo stan & Diag of transv bhd***	-0.188	0.83	44		40.8	-560	4	25	0
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	24		40.8	1841	4	15	0

A.	TOTAL ESTIMATED SCANTLING WT:		54811	4.88	18.72	0.00
B.	DESIGN TARGET WEIGHT (30LT):		67200			
C.	DELTA WT = (A-B):	(-)	12389 (**)			
D.	DELTA WT IN % OF B:	(-)	18.44 (**)			

NOTES:
(*) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(**) VALUES INDICATED WITH (-) ARE UNDER THE DESIGN TARGET WT (B)
FOR SCANTLING ARRANGEMENT SEE FIGURE #3-2

TABLE 3-6

ESTIMATED WEIGHT OF MOORING, HANDLING AND CARGO STOWAGE FITTINGS (NOTE 1) (QUANTITIES & WEIGHTS PER ACB LIGHTER MODULE)

SEE FIG.	FITTING	QTY	WEIGHTS (lbs)		WEIGHTS OF OPTIONAL COMBINATIONS (LBS)			
			ITEM	TOTAL MODULE	1	2	3	4
TRANSPORTATION WEIGHT OF PERMANENTLY INSTALLED FITTINGS								
3-3	TOP CORNER FTG	4	27	108	108	108	108	108
3-4	BOT CORNER FTG	4	27	108	108	108	108	108
3-6	LIFTING PAD	4	93	372	372	372	372	372
3-7	FLUSH DK SOCKET	12	46	552	552	552	---	---
3-8	FLUSH D-RING	8	36	288	288	288	---	---
3-9	RAISED DK SOCKET	12	40	480	---	---	480	480
3-10	RAISED D-RING	8	18	144	---	---	144	144
3-12	BOLTED KEVEL CLEAT (NOTE 2)	4	100	400	---	400	---	400
3-13	HINGED KEVEL CLEAT	4	450	1800	1800	---	1800	---
---	TOTAL WT PER MODULE OF 4 OPTIONS				3228	1828	3012	1612
---	WATERBORNE WEIGHT OF FULLY ASSEMBLED FITTINGS							
---	BOLTED KEVEL CLEAT (NOTE 3)	4	250	1000	---	1000	---	1000
---	TOTAL WT PER MODULE OF 4 OPTIONS				3228	2828	3012	2612

NOTES:

1. Excluding removable adaptor frame for the raked module (see Table 3-7.2)
2. Weight of cleat foundation(s) only
3. Weight of bolted cleat(s) removed for transportation

TABLE 3-7

ESTIMATED LIGHTSHIP WEIGHT OF THE MODULAR ACB LIGHTER (UNPOWERED)

ITEM #	DESCRIPTION	QTY PER ACB-L	WT PER ACB LIGHTER (LBS)	WT % OF ITEMS	SEE NOTE
1	Raked (Bow) Module	1	74,231	36.82	1
2	Center Module	1	87,975	43.64	2
3	Raked (Stern) Module	1	74,231	36.82	1
4	Est Lightship WT of ACB Lighter (Items 1, 2 & 3)	1	236,437	117.28	--
5	Design Target WT for ACB Lighter (3 x 30 = 90 LT)	1	201,600	100	--
6	Total Delta Weight (Item 5 - Item 4)	1	34,837	17.28	3

NOTES:

1. See Item 9b of Table 3-7.2
2. See Item 9 of Table 3-7.1
3. Delta weight of 34,837 lbs is in excess of 201,600 lbs, the original design target wt (Item 5) for the lighter.

TABLE 3-7.1

ACB LIGHTER SUMMARY OF ESTIMATED WEIGHTS FOR "CENTER MODULE"

ITEM #	DESCRIPTION	QTY PER MODULE	UNIT WT (LBS)	WT PER MODULE (LBS)	WT % OF ITEM 10	SEE NOTE
1	Hull Structure	1	58,411	58,411	86.92	1
2	Rigid Connector Assembly (End)	4	3,000	12,000	17.86	2
3	Rigid Connector Assembly (Side)	4	3,000	12,000	17.86	2
4	Flexor Type Connector Assembly	---	---	---	---	--
5	Fittings	Set	3,228	3,228	4.80	3
6	Welding (1% of Item 1)	1	584	584	.869	4
7	Mill Tolerance	1	584	584	.869	4
8	Painting (2% of Item 1)	1	1,168	1,168	1.74	4
9	Total Estimated WT of Center Module	1	---	87,975	130.91	5
10	Design Target WT (30 LT)	1	---	67,200	100	--
11	Delta Weight (Item 10 - Item 9)	1	---	20,775	30.91	6

NOTES:

1. Lowest estimated scantling weight for center module of the preliminary design by MR&S (See Table 3-5.8).
2. See Section 3.2.1.1
3. See Table 3-6
4. Weight budget for welding, mill tolerance and painting is based on shipyard estimating practices.
5. Extimated handling & lightship weight
6. Delta weight of 20,775 lbs is in excess of the original 67,200 lbs (Item 10) design weight criteria for handling.

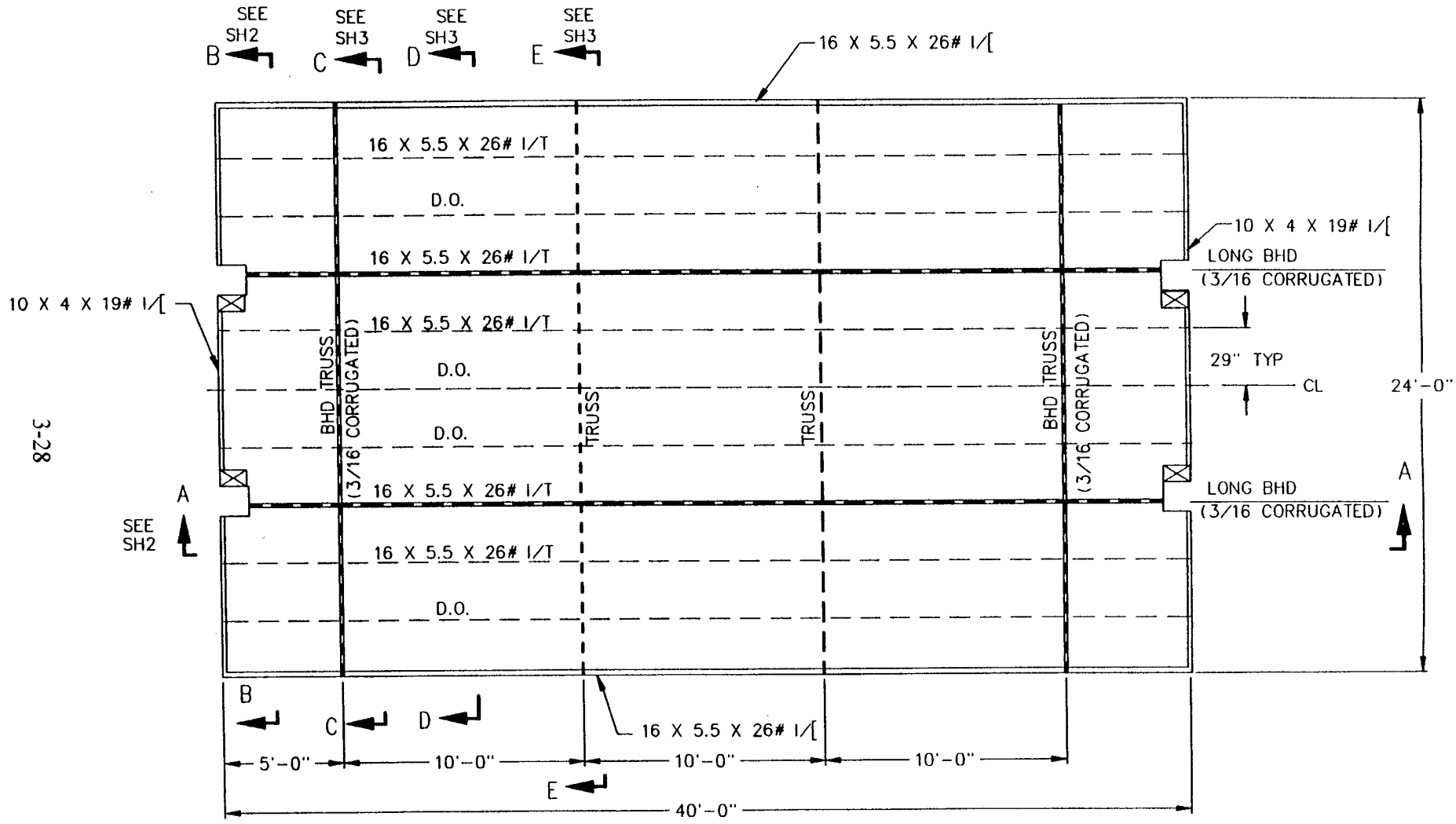
TABLE 3-7.2

ACB LIGHTER SUMMARY OF ESTIMATED WEIGHTS FOR "RAKED MODULE" (BOW OR STERN)

ITEM #	DESCRIPTION	QTY PER MODULE	UNIT WT (LBS)	WT PER MODULE (LBS)	WT % OF ITEM 10	SEE NOTE
1	Hull Structure	1	58,411	58,411	81.56	1
2	Rigid Connector Assembly (End)	2	3,000	6,000	8.93	2(a)
3	Rigid Connector Assembly (Side)	2	3,000	6,000	8.93	2(a)
4	Flexor Type Connector Assembly	2	1,000	2,000	2.98	2(b)
5a	Fittings	Set	3,228	3,228	4.80	3a
5b	Removable Adaptor Frame	1	800	800	1.19	3b
6	Welding (1% of Item #1)	1	548	548	0.815	4
7	Mill Tolerance (1% of Item #1)	1	548	548	0.815	4
8	Painting (2% of Item #1)	1	1,096	1,096	1.63	4
9a	Total Estimated Handling WT of Raked Module	1	---	75,031	111.65	--
9b	Estimated Lightship Weight of Raked Module (9a - 5b)	1	---	74,231	110.46	5
10	Design Target (30 LT)	1	---	67,200	100	--
11	Delta Weight (Handling) (9a - 10)	1	---	7,831	11.65	6

NOTES:

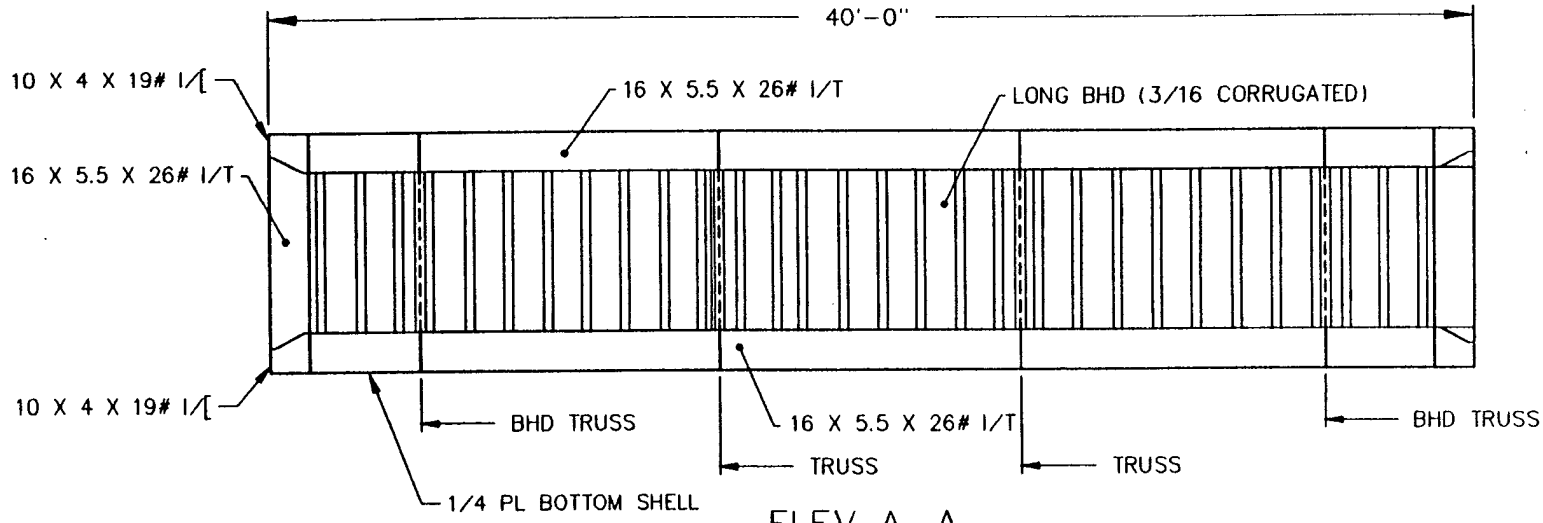
1. Lowest estimated scantling for raked module weight of this preliminary design by MR&S (See Table 3-5.9).
2a. See Section 3.2.1.1
2b. See Section 3.2.1.2
3a. See Table 3-6
3b. Estimated removable adapter frame weight (see Section 3.2.2.2)
4. Weight budget for welding, mill tolerances and painting is based on shipyard estimating practices.
5. See Section 6.1
6. Delta weight of 7,831 lbs is in excess of the 67,200 lbs (Item 10) design weight criteria for handling.



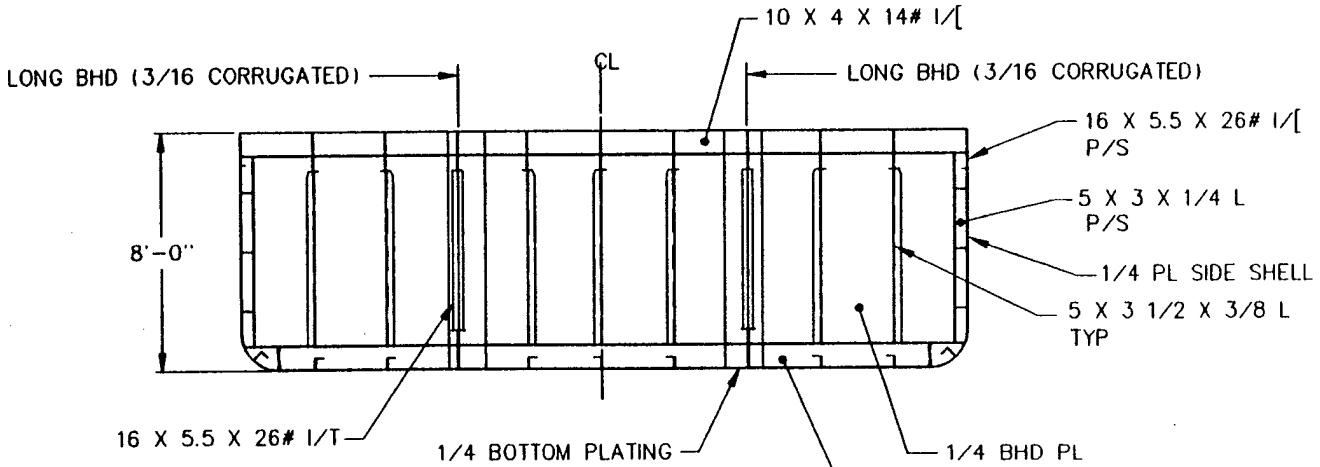
PLAN VIEW

ACB LIGHTER CENTER MODULE SCANTLING ARRANGEMENT

FIGURE 3-1
(SH 1 OF 3)



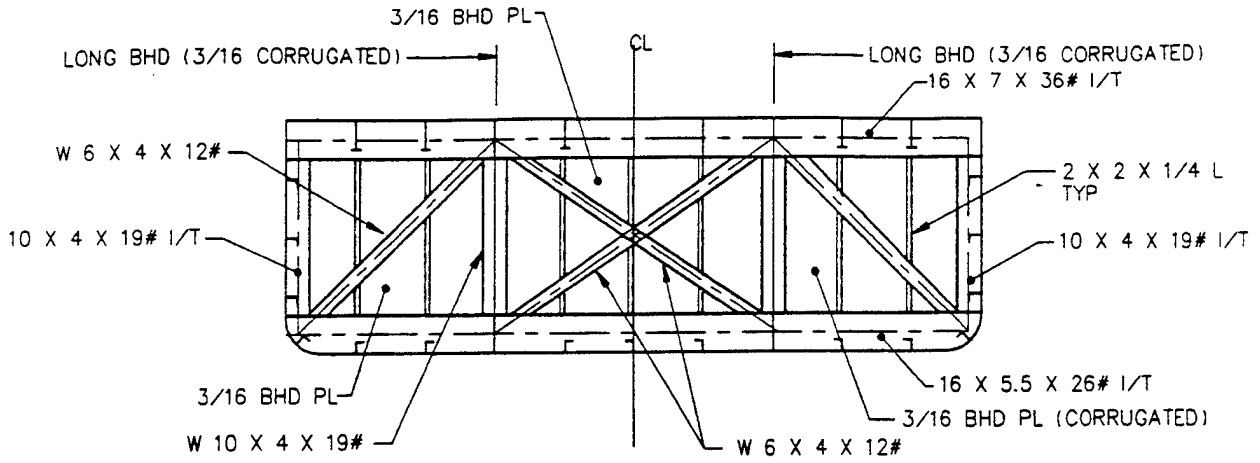
ELEV A-A
TYPICAL CORRUGATED LONG BHD



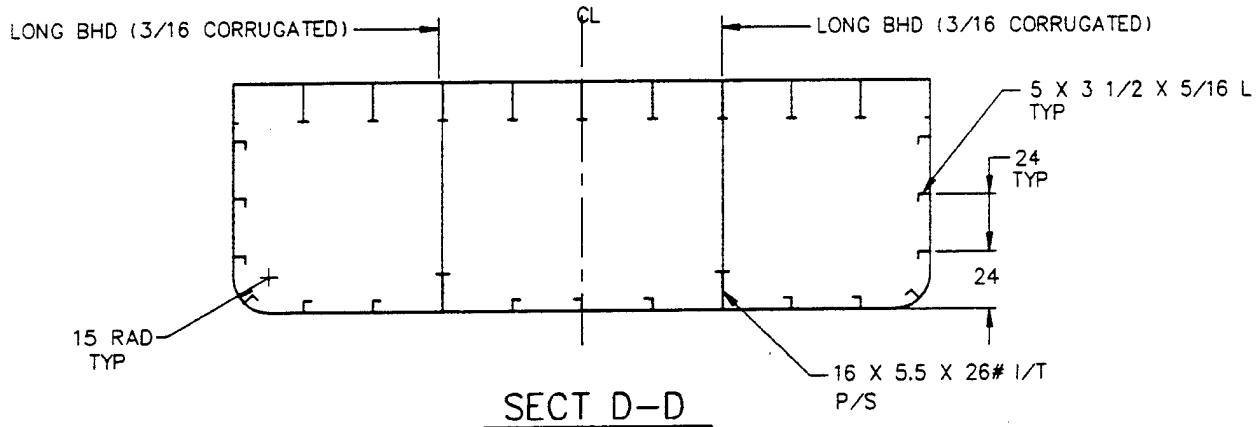
SECT B-B
END FRAME

ACB LIGHTER CENTER MODULE SCANTLING DETAILS

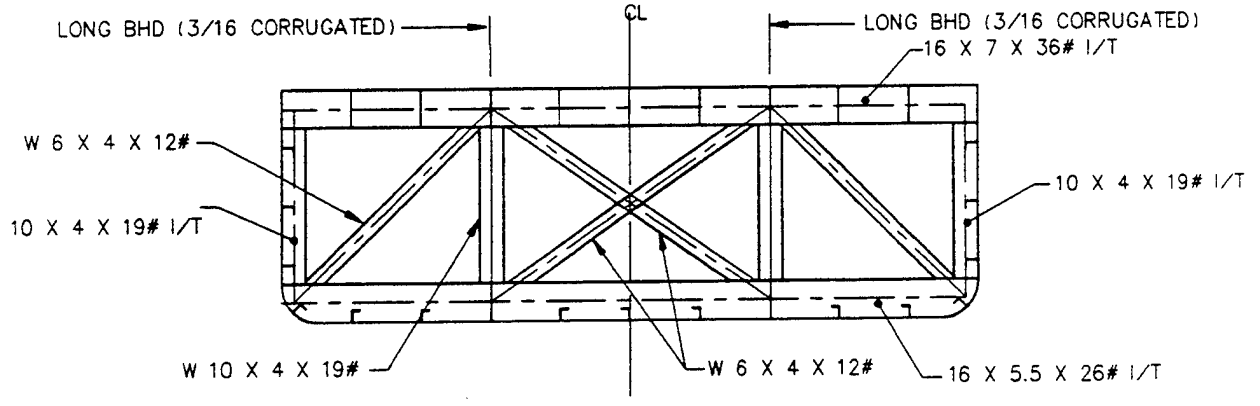
FIGURE 3-1
(SH 2 OF 3)



SECT C-C
TYPICAL BHD TRUSS



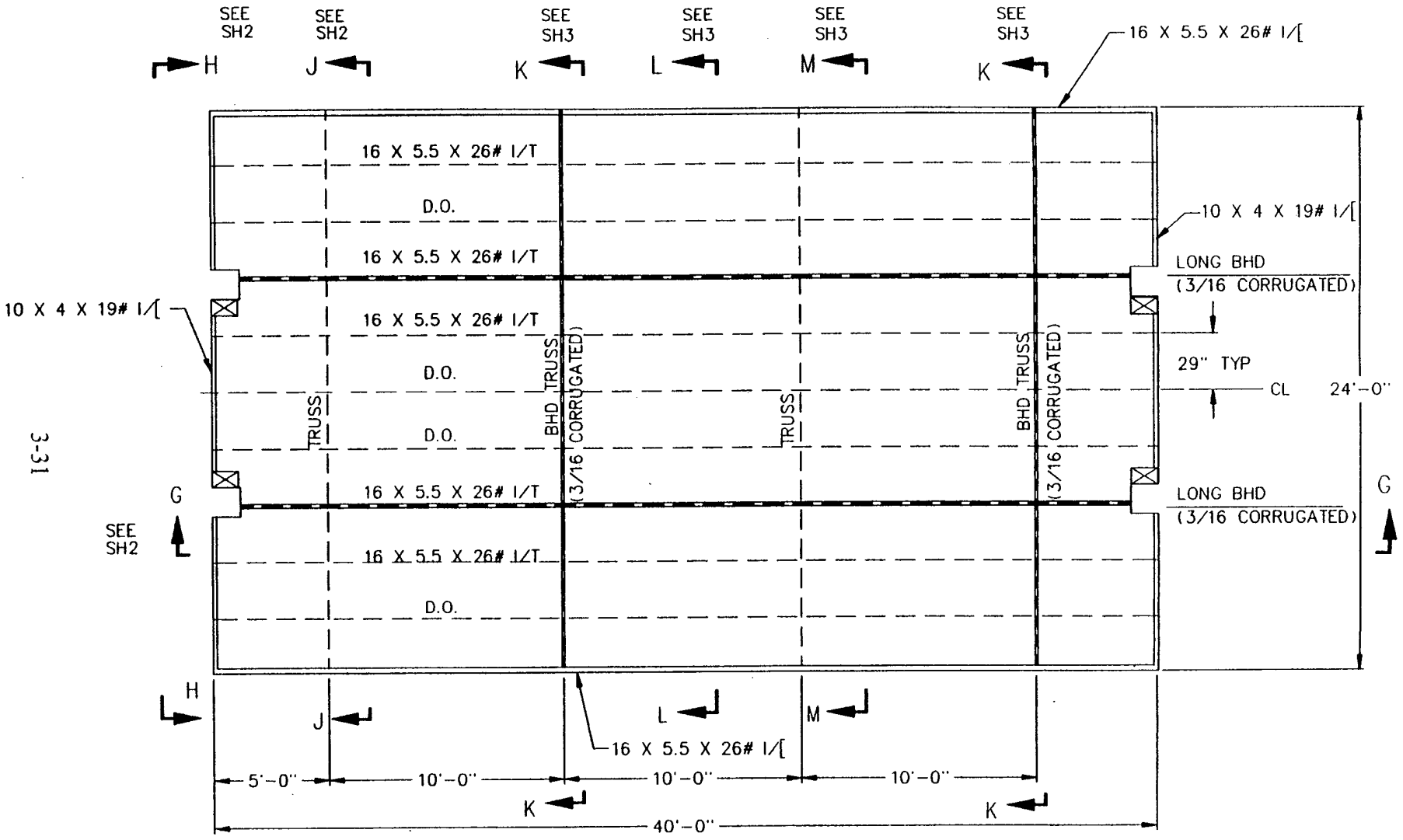
SECT D-D
TYPICAL CROSS SECTION



SECT E-E
TYPICAL TRUSS

ACB LIGHTER CENTER MODULE SCANTLING DETAILS

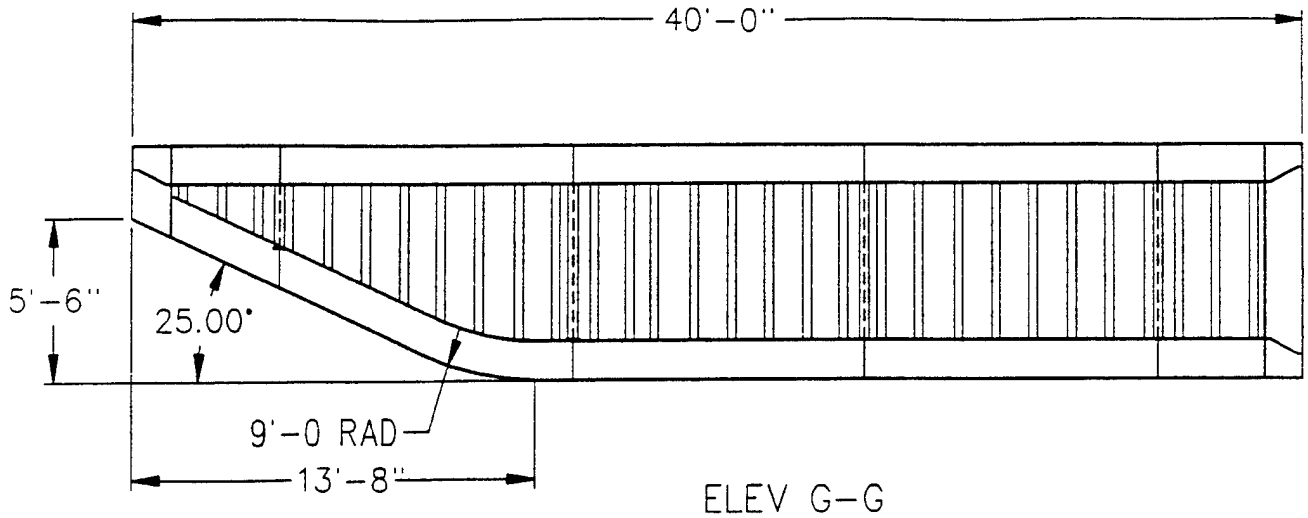
FIGURE 3-1
(SH 3 OF 3)



PLAN VIEW F-F

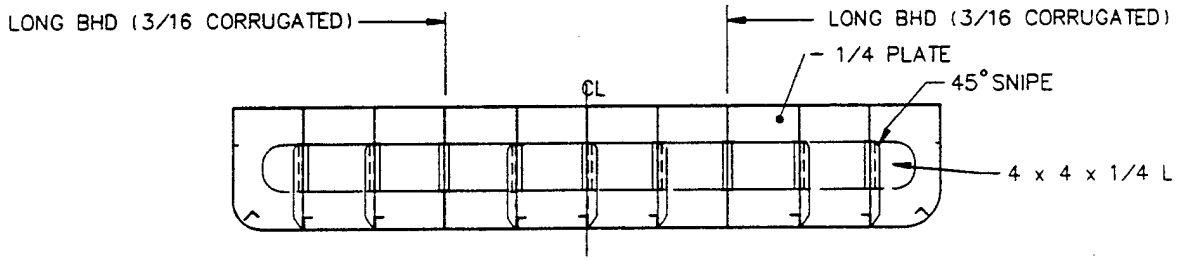
ACB LIGHTER RAKED MODULE SCANTLING ARRANGEMENT

FIGURE 3-2
(SH 1 OF 3)



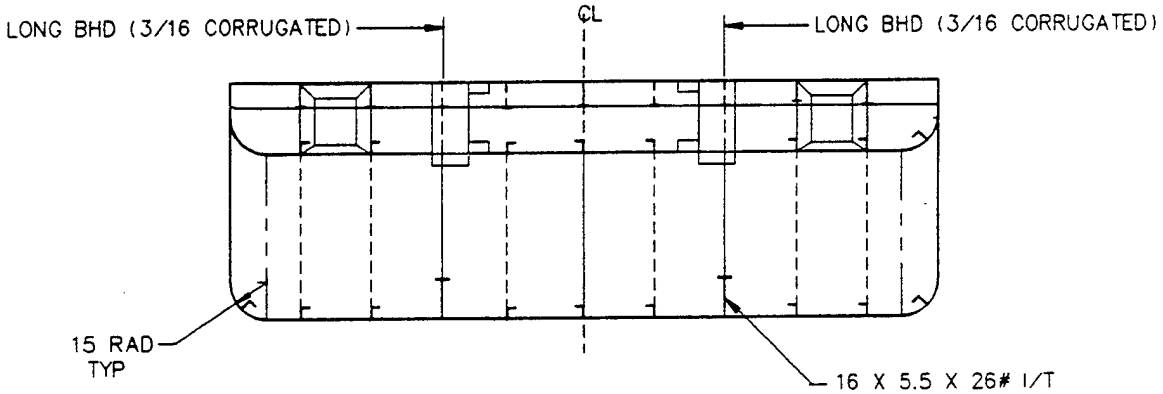
ELEV G-G

TYPICAL CORRUGATED LONG BHD



SECT J-J

TRUSS SECTION

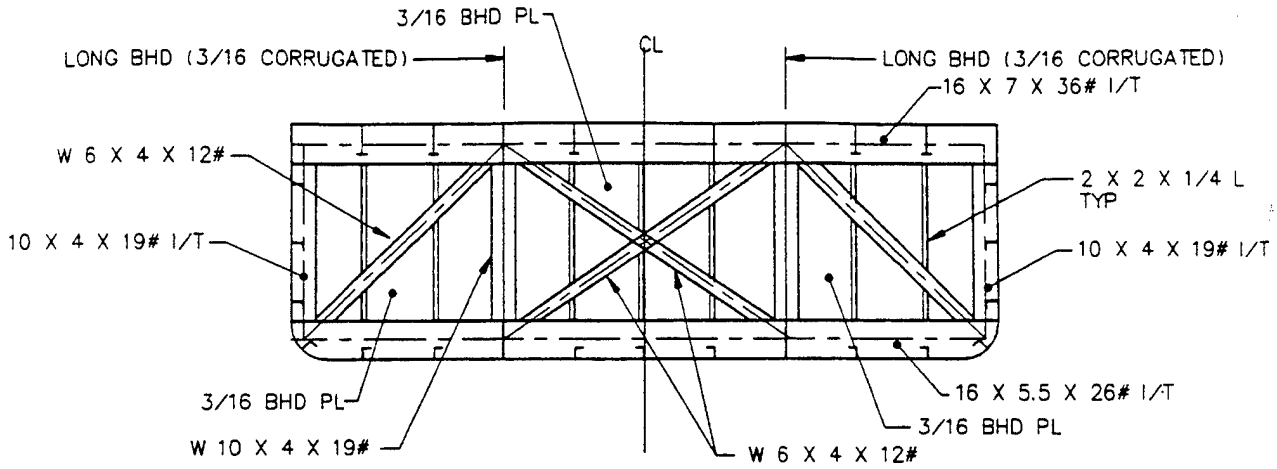


END H-H

END FRAME

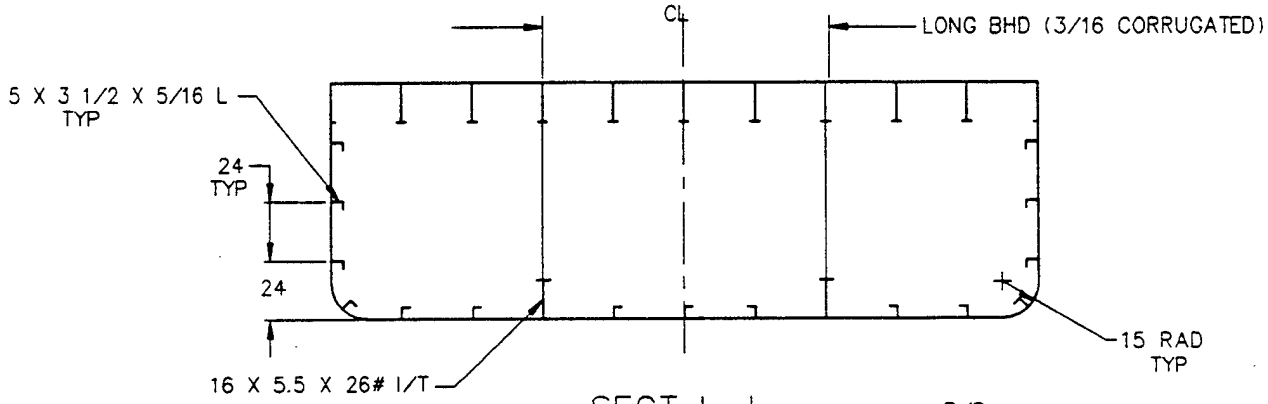
ACB LIGHTER RAKED MODULE SCANTLING DETAILS

FIGURE 3-2
(SH 2 OF 3)



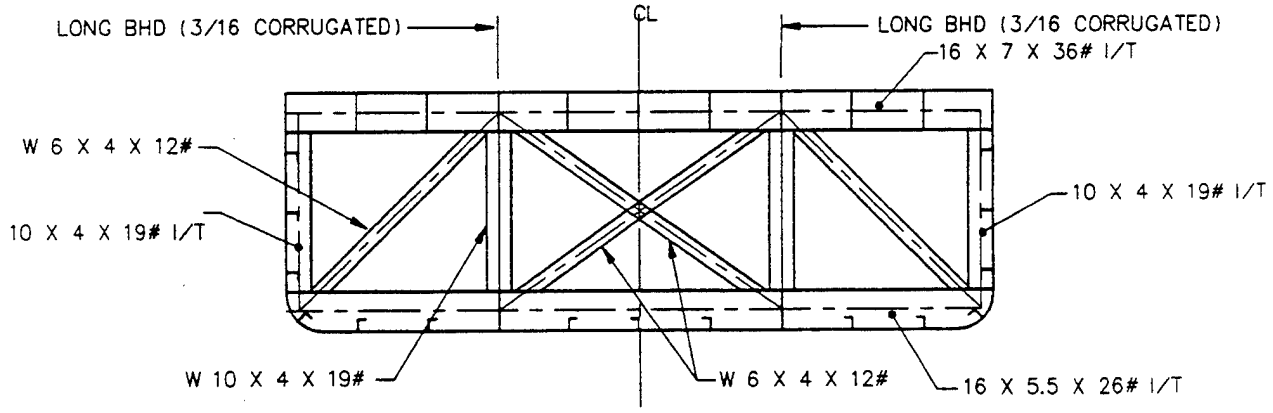
SECT K-K

TYPICAL BHD TRUSS



SECT L-L P/S

TYPICAL CROSS SECTION



SECT M-M

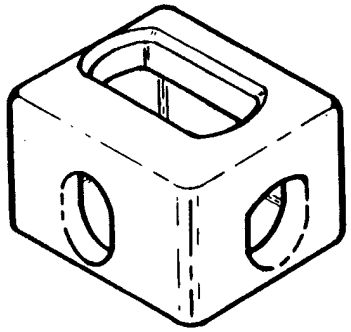
TRUSS SECTION

ACB LIGHTER RAKED MODULE SCANTLING DETAILS

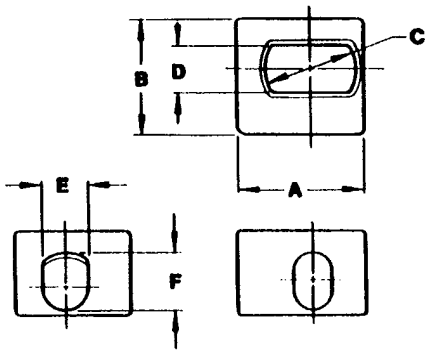
FIGURE 3-2
(SH 3 OF 3)

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



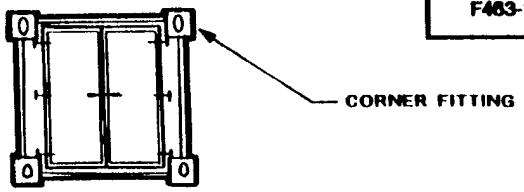
SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
MEETS STRENGTH REQUIREMENTS OF I.S.O. STANDARD 1161

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F463-1	MM	178.0	162.0	123.8	63.5	63.5	73.0	12.3
	(INCH)	(7.00)	(6.38)	(4.87)	(2.50)	(2.50)	(2.87)	(27.0)



APPLICATION

F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)

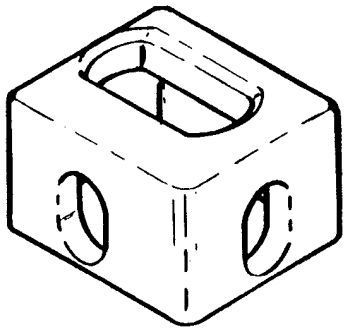
PECK & HALE, INC.
180 DIVISION AVENUE
WEST BABYLON, N.Y. 11796 USA

FSCM NO:94858	DRN: S.M.	SHEET OF	
DATE: 10/23/91	APPD: S.J.	2023	REV
SCALE: NONE	Q.C.:	DWG NO	

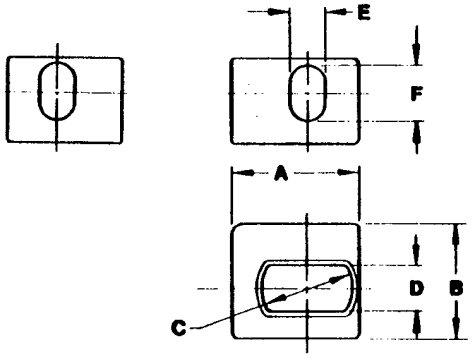
FIGURE 3-3

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F463
CORNER FITTING
(BOTTOM I.S.O. CORNER FITTING)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



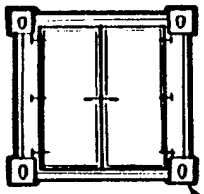
SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
MEETS STRENGTH REQUIREMENTS OF I.S.O. STANDARD 1161

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F463-2	MM	178.0	162.0	123.8	63.5	50.8	79.4	12.3
	(INCH)	(7.00)	(6.38)	(4.87)	(2.50)	(2.00)	(3.13)	(27.0)



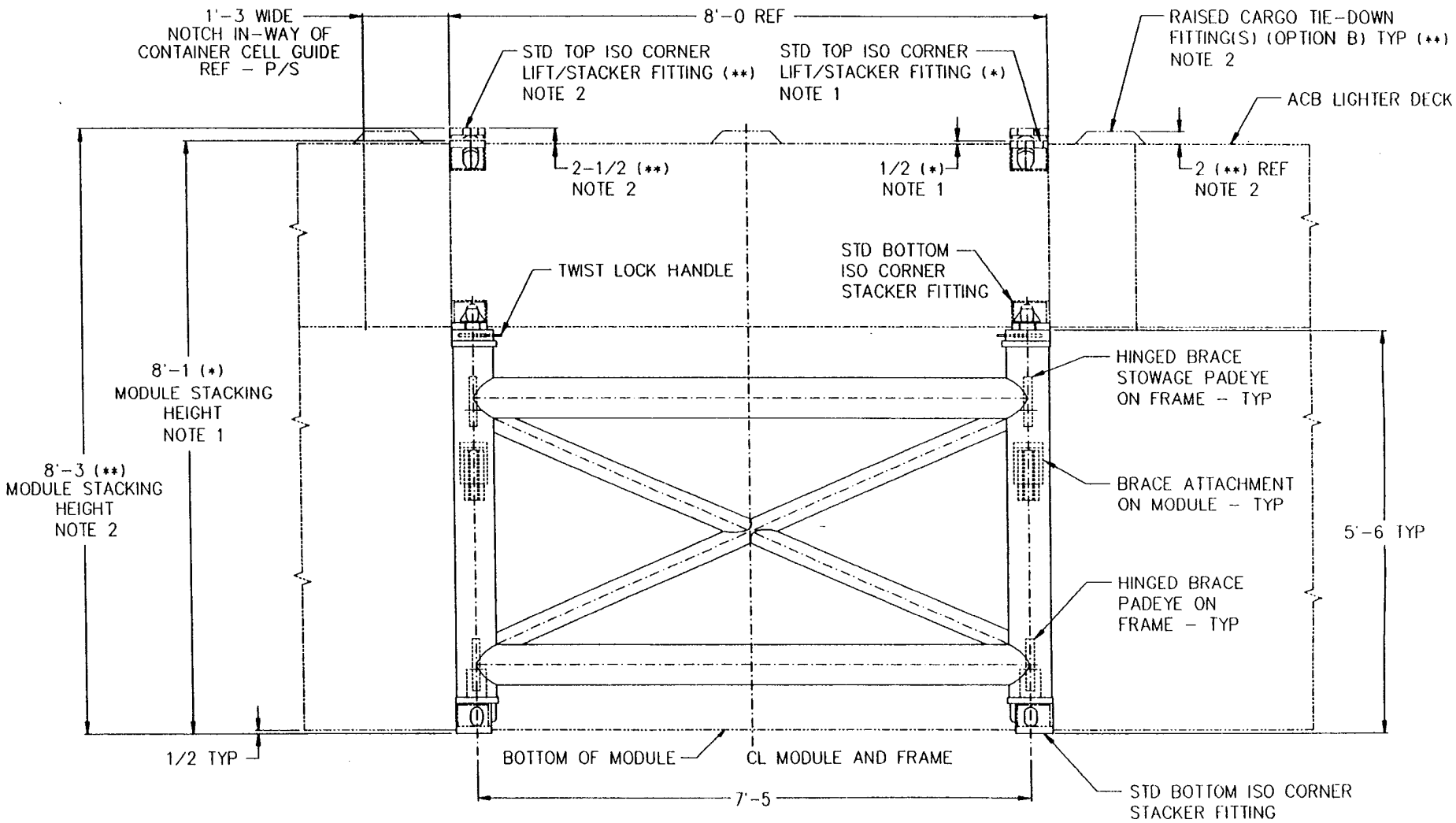
APPLICATION

F463
CORNER FITTING
(BOTTOM I.S.O. CORNER FITTING)

PECK & HALE, INC.
100 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94658	DRN: S.M.	SHEET OF	
DATE: 10/24/91	APPD: S.J.	2023 DWG NO	REV
SCALE: NONE	Q.C.:		

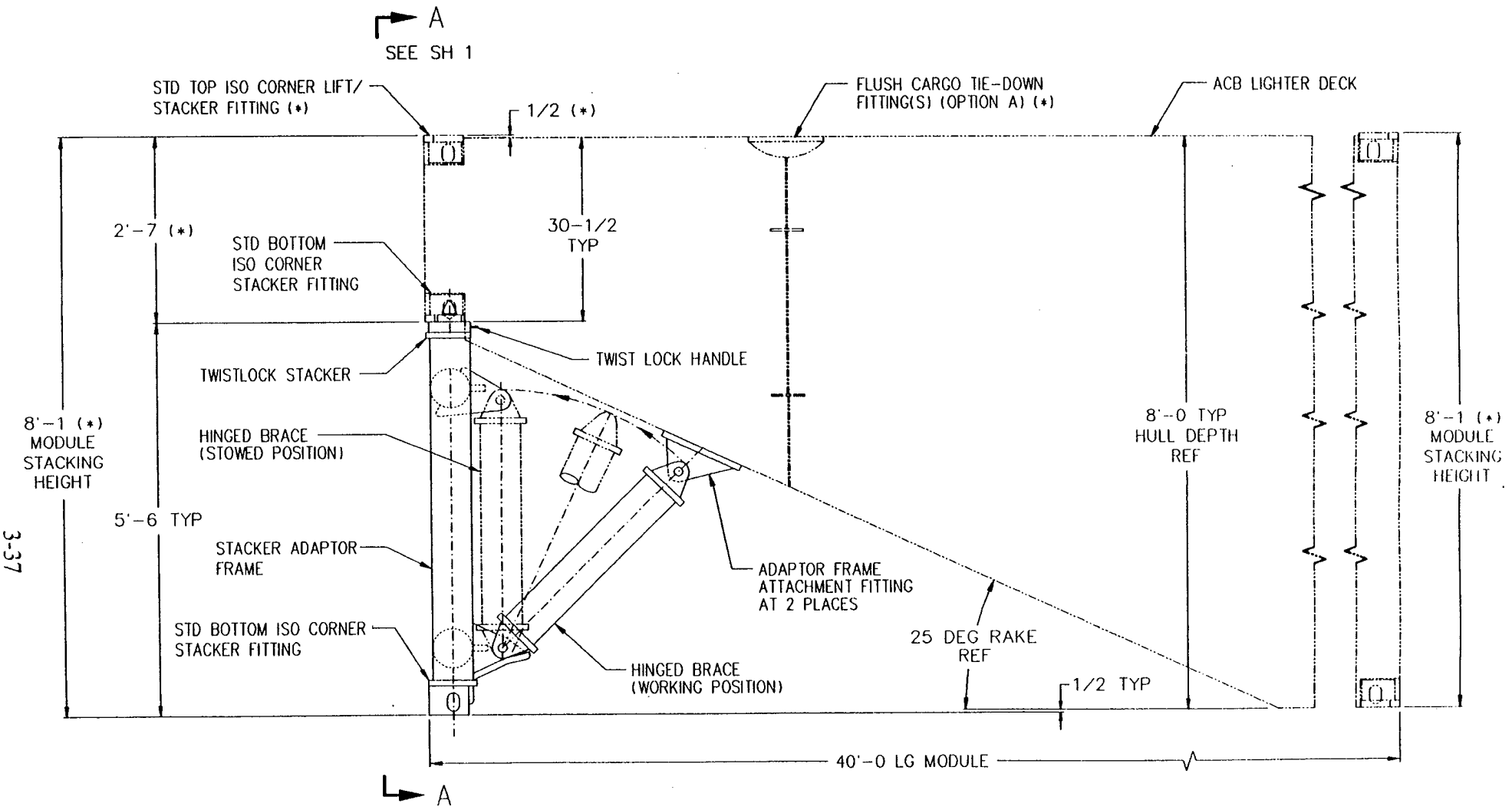
FIGURE 3-4



ACB LIGHTER RAKED MODULE STACKER ADAPTOR FRAME

NOTES: 1) STACKING HEIGHT 8'-1, AND DIMENSIONS INDICATED WITH (*) ARE FOR FLUSH TYPE CARGO TIEDOWN FITTINGS (OPTION A)
2) STACKING HEIGHT 8'-3, AND DIMENSIONS INDICATED WITH (**) ARE FOR RAISED TYPE CARGO TIEDOWN FITTINGS (OPTION B)

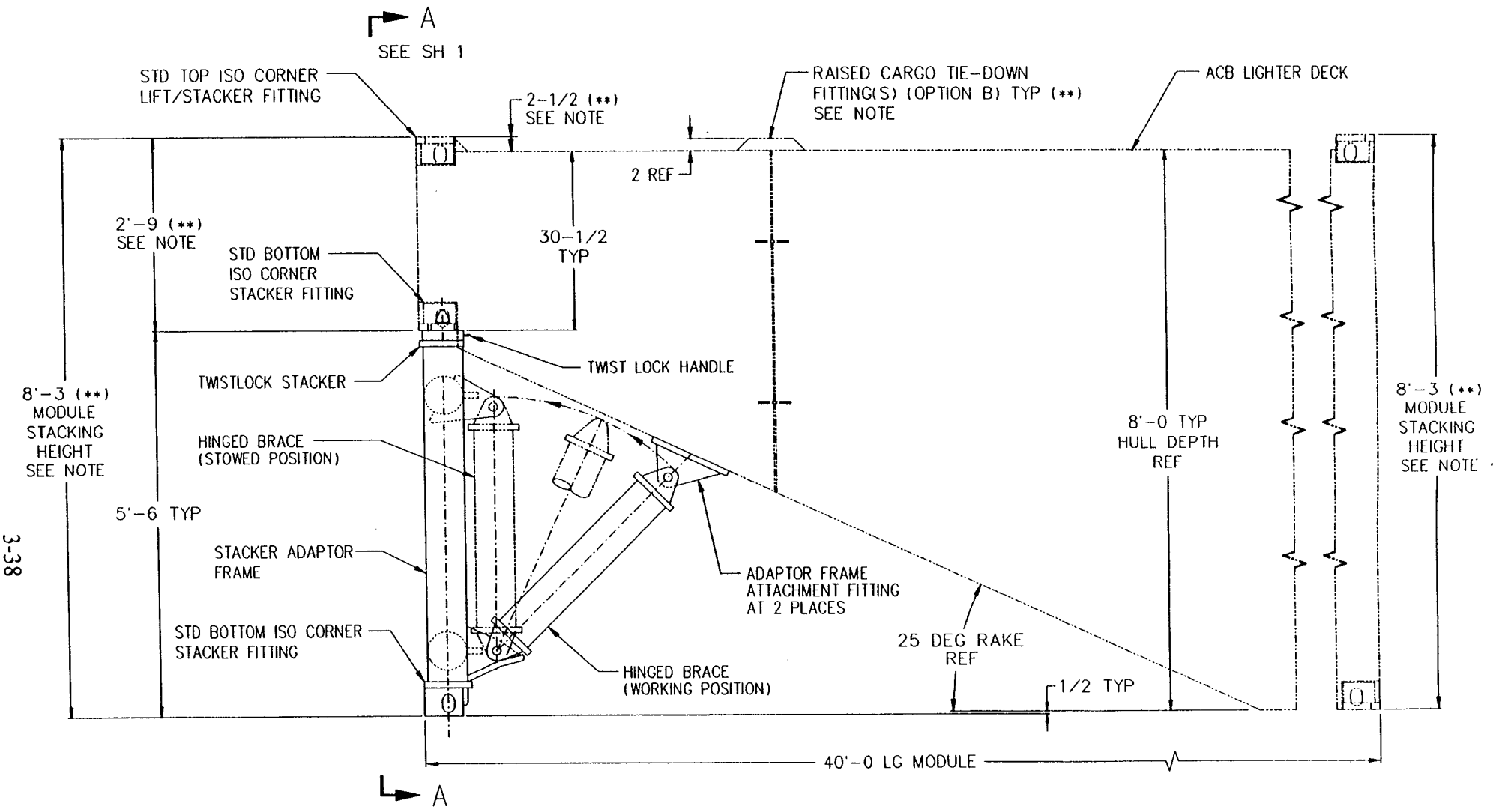
FIGURE 3-5
SH 1 OF 3



ACB LIGHTER RAKED MODULE STACKER ADAPTOR FRAME

NOTE: STACKING HEIGHT 8'-1, AND DIMENSIONS INDICATED WITH (*) ARE FOR FLUSH TYPE CARGO TIEDOWN FITTINGS (OPTION A)

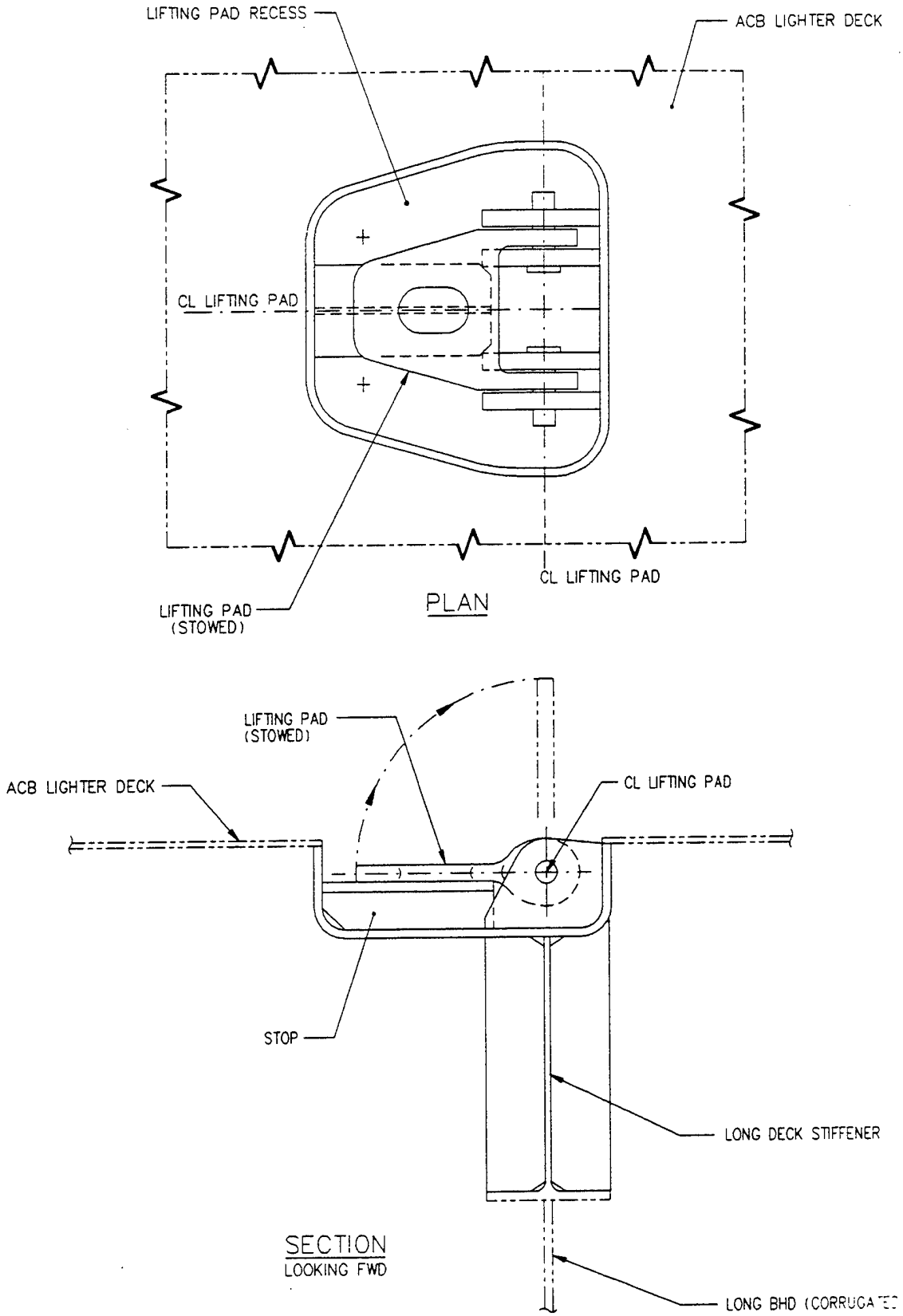
FIGURE 3-5
SH 2 OF 3



ACB LIGHTER RAKED MODULE STACKER ADAPTOR FRAME

NOTE: STACKING HEIGHT 8'-3, AND DIMENSIONS INDICATED WITH (**) ARE FOR RAISED TYPE CARGO TIEDOWN FITTINGS (OPTION B)

FIGURE 3-5
SH 3 OF 3

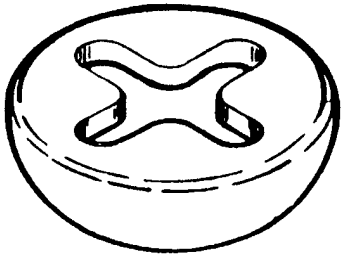


HINGED LIFTING PAD

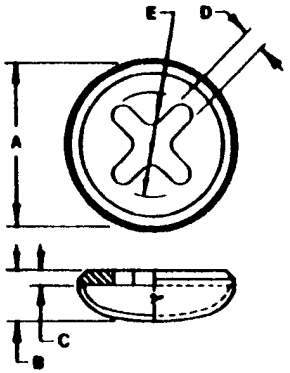
FIGURE 3-6

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD
EWO 3006				

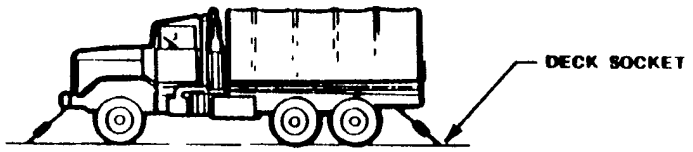
F517
DECK SOCKET
(FLUSH CLOVERLEAF)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



MODEL NO.	DIM	A	B	C	D	E	WT KGS. (LBS.)
F517-1E	MM	247.7	74.6	12.7	35.0	155.6	9.5
	(INCH)	(9.75)	(2.94)	(0.50)	(1.38)	(6.13)	(21.0)



APPLICATION

SPECIFICATIONS

MATERIAL:
TOP PLATE - STEEL (AH-36)
CUP - STEEL (A36)

STRENGTH:
35,000 lbs. M.B.S. PULL AT 45° PER SLOT

TESTING:
MIN. BREAK TESTED: 1 OF 250 TO 35,000 lbs

FINISH:
SELF COLOR

F517
DECK SOCKET
(FLUSH CLOVERLEAF)

Peck & Hale

PECK & HALE, INC.
WEST BABYLON, N.Y. 11704 USA

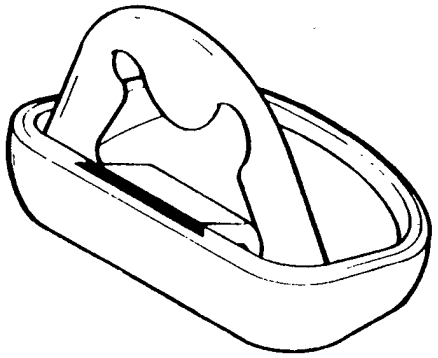
FBCM NO: 94858	DRN: S.M.	SHEET OF	
DATE: 4-12-94	APPD: S.H.	3388	REV
SCALE: NONE	Q.C.:	DWG NO	

FIGURE 3-7

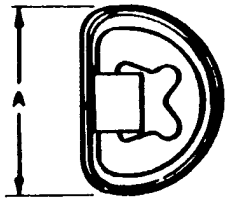
NEXT ASSEMBLY

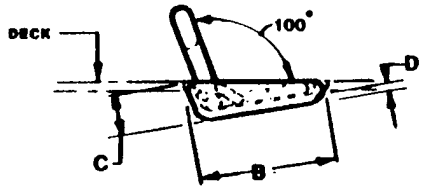
ISSUE	REVISION RECORD	DATE	APPD

F718
D-RING
(FLUSH CLOVERLEAF)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES





MODEL NO.	DIM	A	B	C	D	WT KGS (LBS.)
F718-1-1	MM	254.0	203.2	50.8	12.7	17.9
	(INCH)	(10.0)	(8.0)	(2.0)	(0.5)	(8.0)

APPLICATION

SPECIFICATIONS

MATERIAL:
D-RING: FORGED STEEL
CUP: CAST STEEL

STRENGTH:
35,000 LBS. M.B.S. AT 45° PULL PER SLOT

FINISH:
SELF COLORED

F718-2
D-RING
(FLUSH CLOVERLEAF)

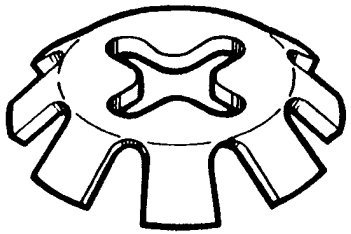
Peck & Hale
PECK & HALE, INC.
100 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94656	DRN: F.R.M.	SHEET OF	
DATE: 6/21/91	APPD: S.J.	3931 DWG NO	REV
SCALE: NONE	O.C.:		

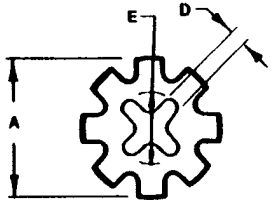
FIGURE 3-8

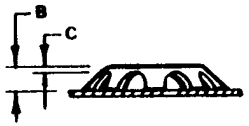
NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F265
DECK SOCKET
(RAISED CLOVERLEAF)

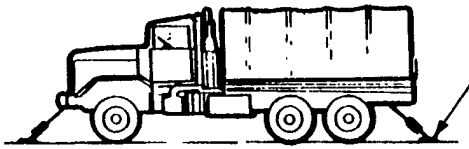


DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES





MODEL NO.	DIM	A	B	C	D	E	WT KGS. (LBS.)
F265-1C	MM	292.0	51.0	12.7	35.0	155.6	
	(INCH)	(11.50)	(2.00)	(0.50)	(1.38)	(6.13)	



APPLICATION

SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
35,000 LBS. M.B.S. AT 45° PULL PER SLOT

FINISH:
SELF COLORED

F265
DECK SOCKET
(RAISED CLOVERLEAF)

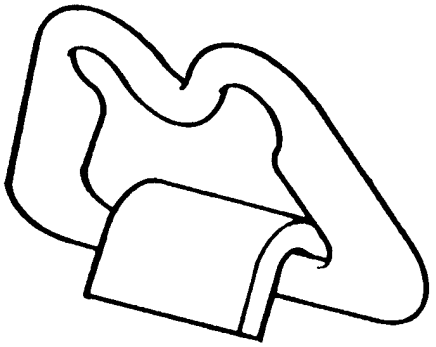
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94858	DRN: S.M.	SHEET OF	
DATE: 10/23/91	APPD: S.J.	3496	
SCALE: NONE	Q.C.:	DWG NO	REV

FIGURE 3-9

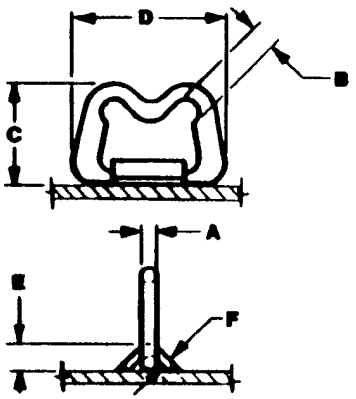
NFX1 ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F677
D-RING & STRAP
(CLOVERLEAF)

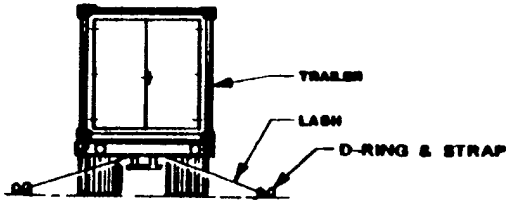


DIMENSIONAL DATA

COMMERCIAL TOLERANCE APPLIES



MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F677-1/-2	MM	20.6	35.0	135.0	209.2	44.6	12.7	2.0
	(INCH)	(.812)	(1.37)	(5.31)	(8.00)	(1.75)	(0.500)	(4.4)



APPLICATION

SPECIFICATIONS

MATERIAL:

D-RING - FORGED STEEL
STRAP - PLATE STEEL

STRENGTH:

35,000 LBS. M.B.S. PULL AT 45° PER SLOT.

TESTING:

PROOF TESTED: 1 OF 50 UNITS TO 23,333 LBS.

FINISH:

BARE MILL STEEL.

F677
D-RING & STRAP
(CLOVERLEAF)

Peck & Hale

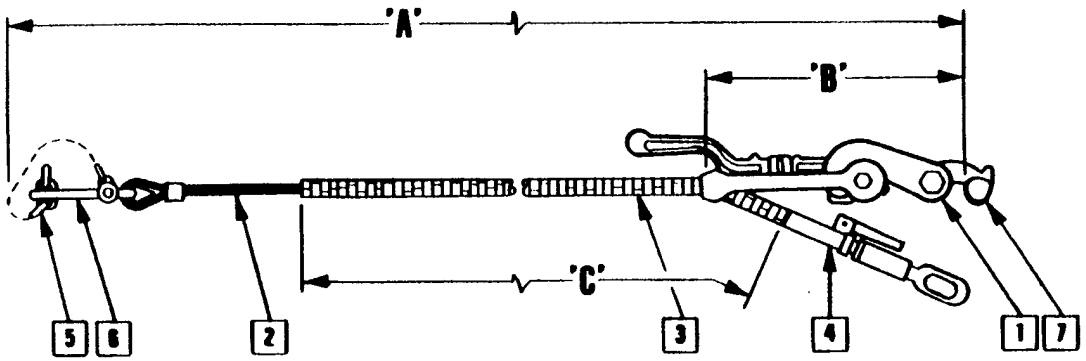
PECK & HALE, INC.
1900 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO: 84868	DRN: S.M.	SHEET OF
DATE: 6-26-83	APPD: S.J.	3524 DWG NO — REV
SCALE:	Q.C.:	

FIGURE 3-10

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

35M/819
TIEDOWN ASSEMBLY
(VEHICLE)



SPECIFICATIONS

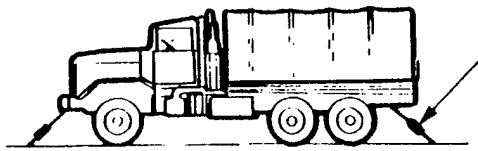
MATERIAL:
ALL CONSTRUCTION IS PER BEST COMMERCIAL QUALITY. SEE CHART BELOW FOR SPECIFIC MATERIAL.

STRENGTH:
35,000 LBS. M.B.S.

TESTING:
ASSEMBLY IS PROOF TESTED TO 17,500 LBS.

FINISH:
ALL SURFACE FINISHES PROVIDE GOOD CORROSION PROTECTION. SEE CHART BELOW FOR SPECIFIC FINISH.

MODEL No.	ADJUSTMENT 'A'	TENSIONER ASSEMBLY		WIRE ROPE ASSEMBLY	
		MODEL No.	'B'	MODEL No.	'C'
35M/819	59.00" TO 126.00"	35M-1/819	16.81"	35M-3/819A	123.00"



APPLICATION

ITEM NO	PART NO	PART NAME	DESCRIPTION
7	H71-1F-1	BULB HOOK	STEEL, GALV
6	PH324-1	CHAIN GRAB	STEEL, GALV
5	PH279-1	CHAIN BRIDLE, 1/2"	STEEL, GALV
4	PH750-8	HIGH TENSION UNIT	CRES
3	PH10-20	SPLIT BEAD	STEEL, CAD PLT
2	-	WIRE ROPE, 5/8" DIA	STEEL, GALV
1	PH4035-1	TENSIONER	STEEL, GALV/ CAD PLT

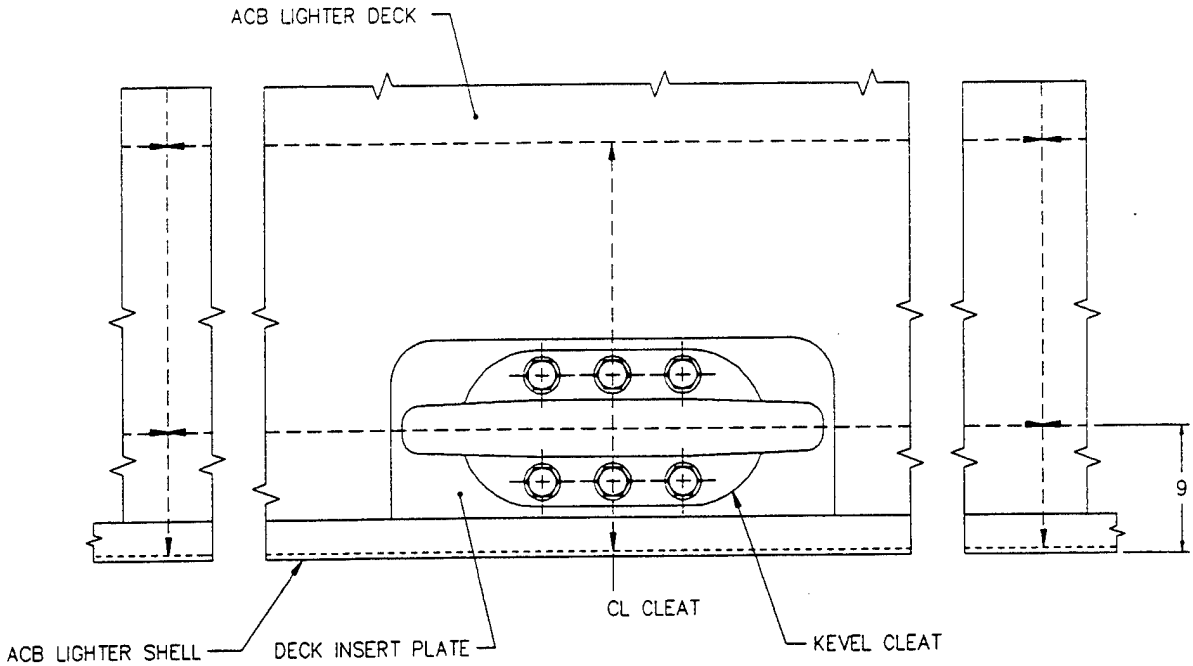
LIST OF MAJOR COMPONENTS

35M/819
TIEDOWN ASSEMBLY
(VEHICLE)

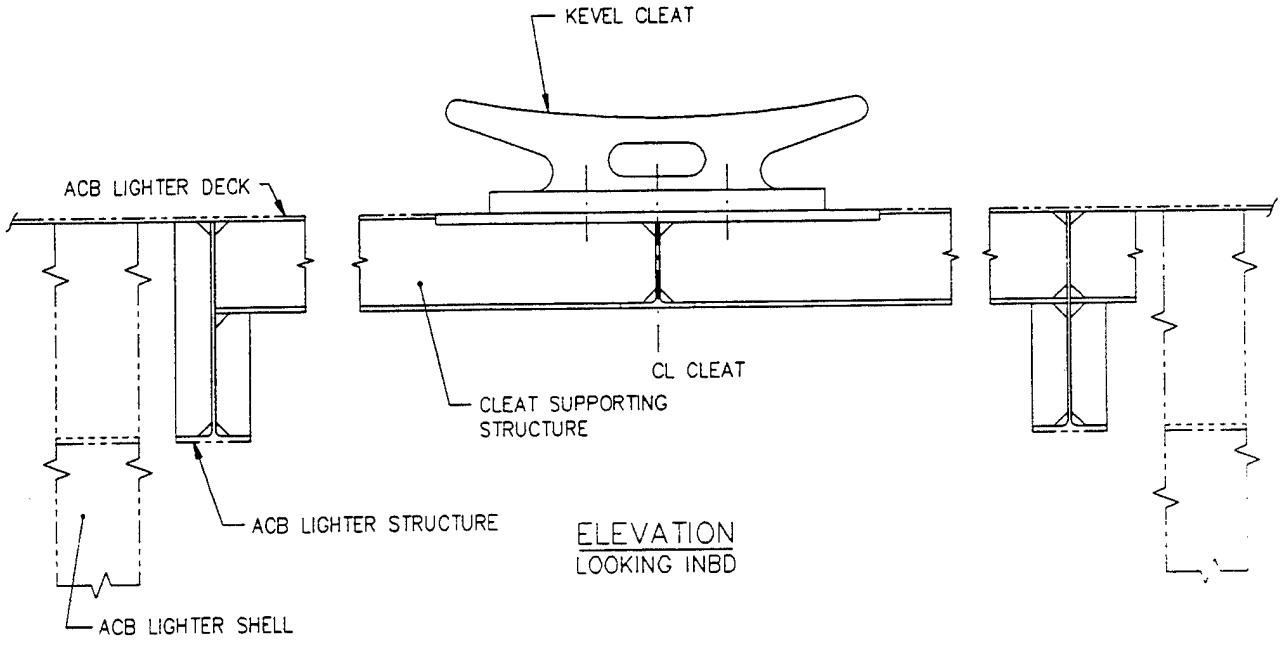
Peck & Hale
PECK & HALE, INC.
100 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO: 94858	DRN: F R M	SHEET OF	
DATE: 7/25/91	APPD: S J	1248	REV
SCALE: NONE	Q.C.:	DWG NO	

FIGURE 3-11



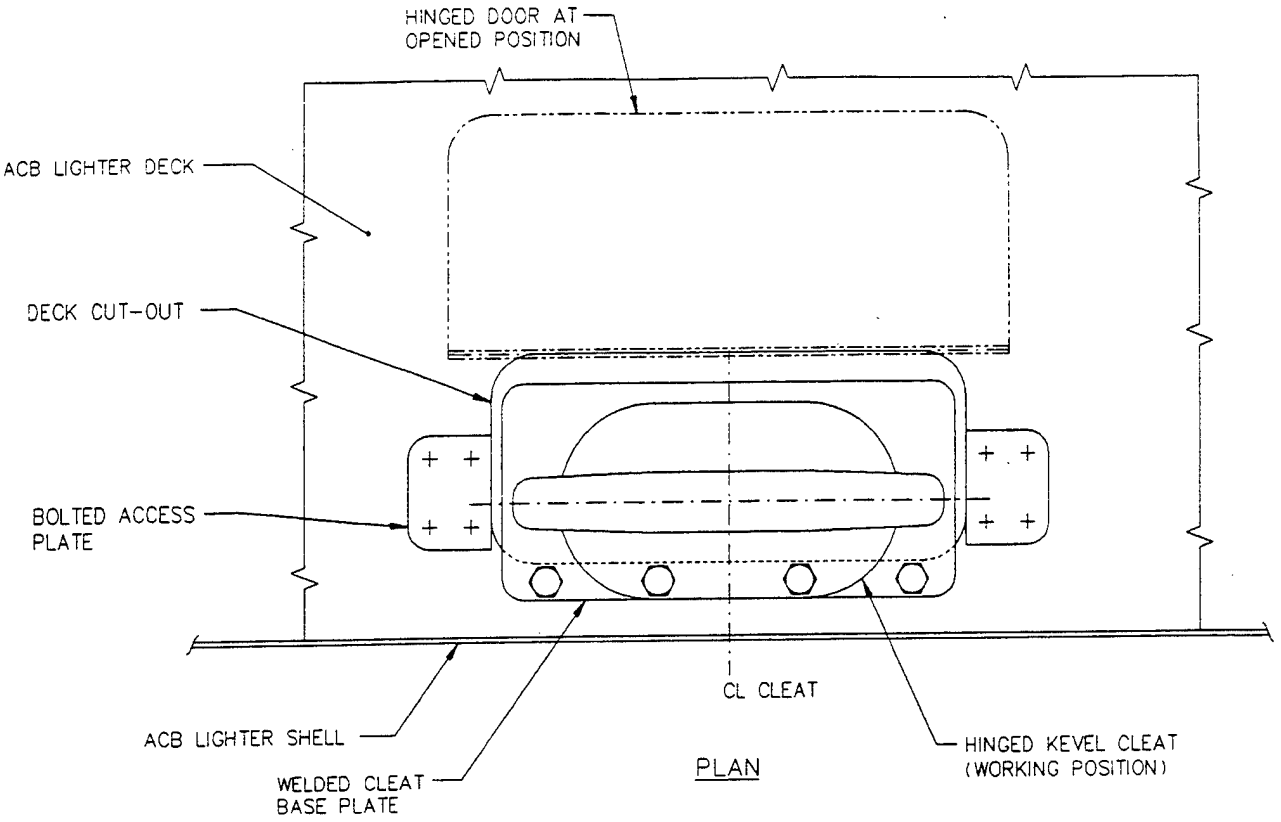
PLAN

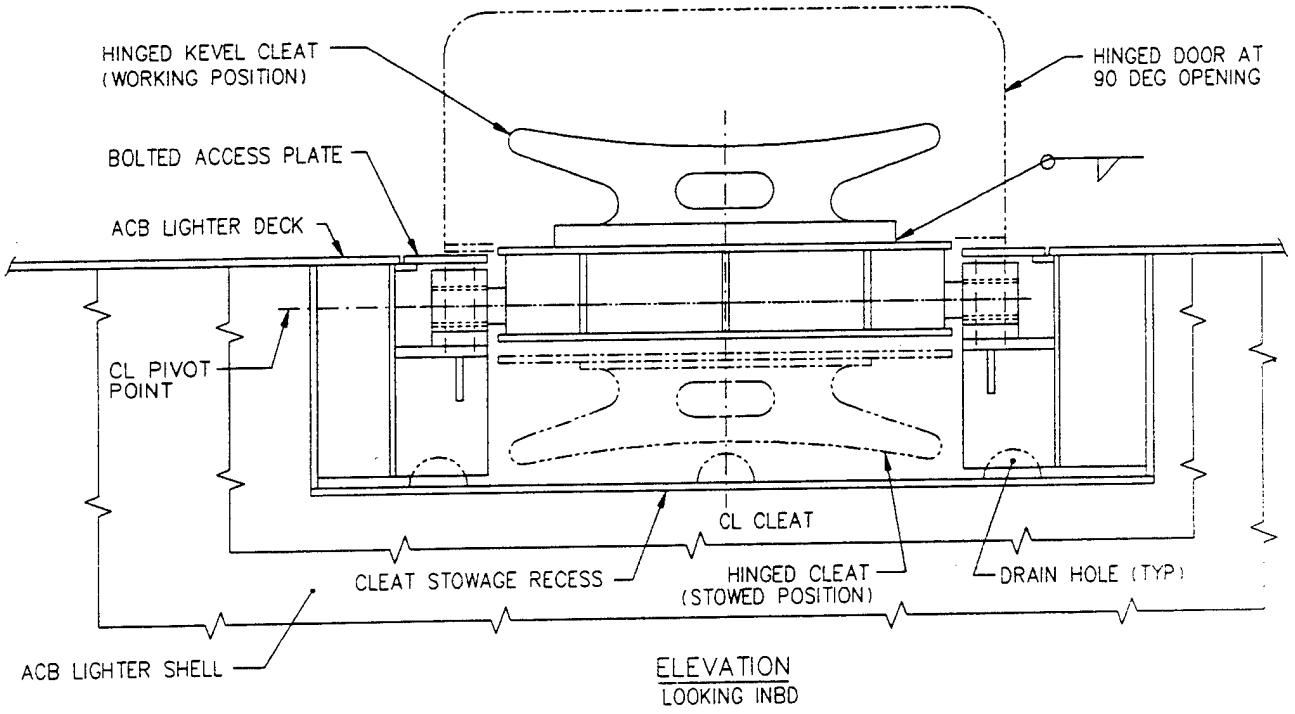


ELEVATION
LOOKING INBD

BOLTED KEVEL CLEAT (REMOVEABLE)

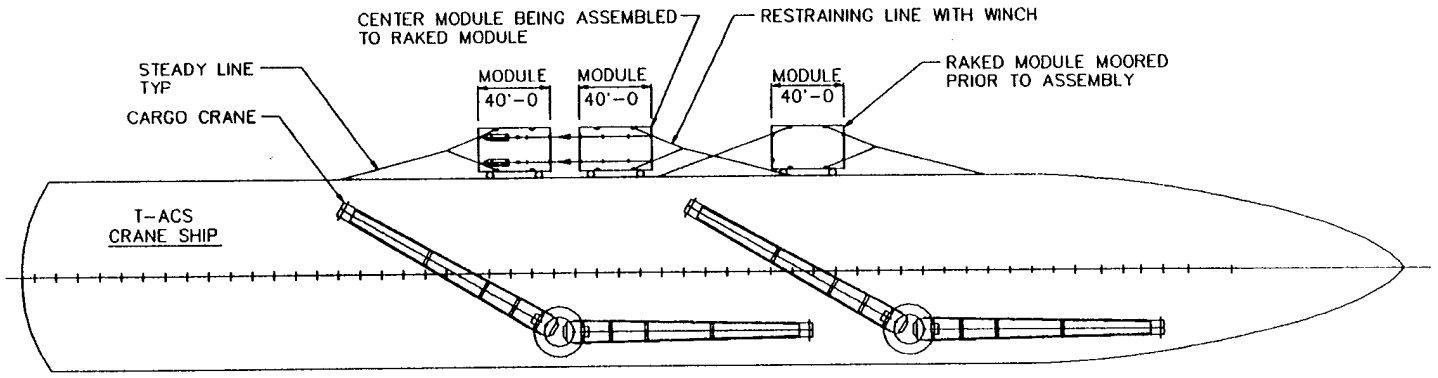
FIGURE 3-12



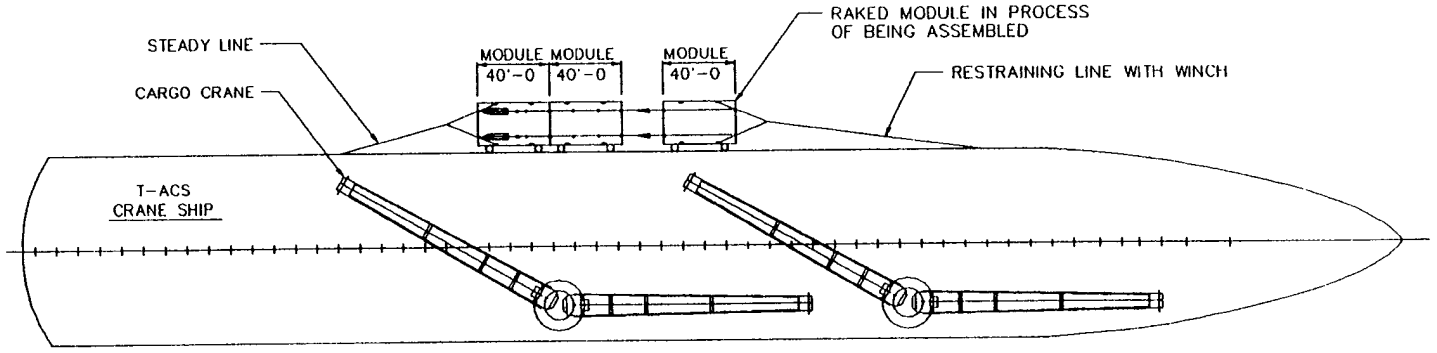


HINGED KEVEL CLEAT

FIGURE 3-13



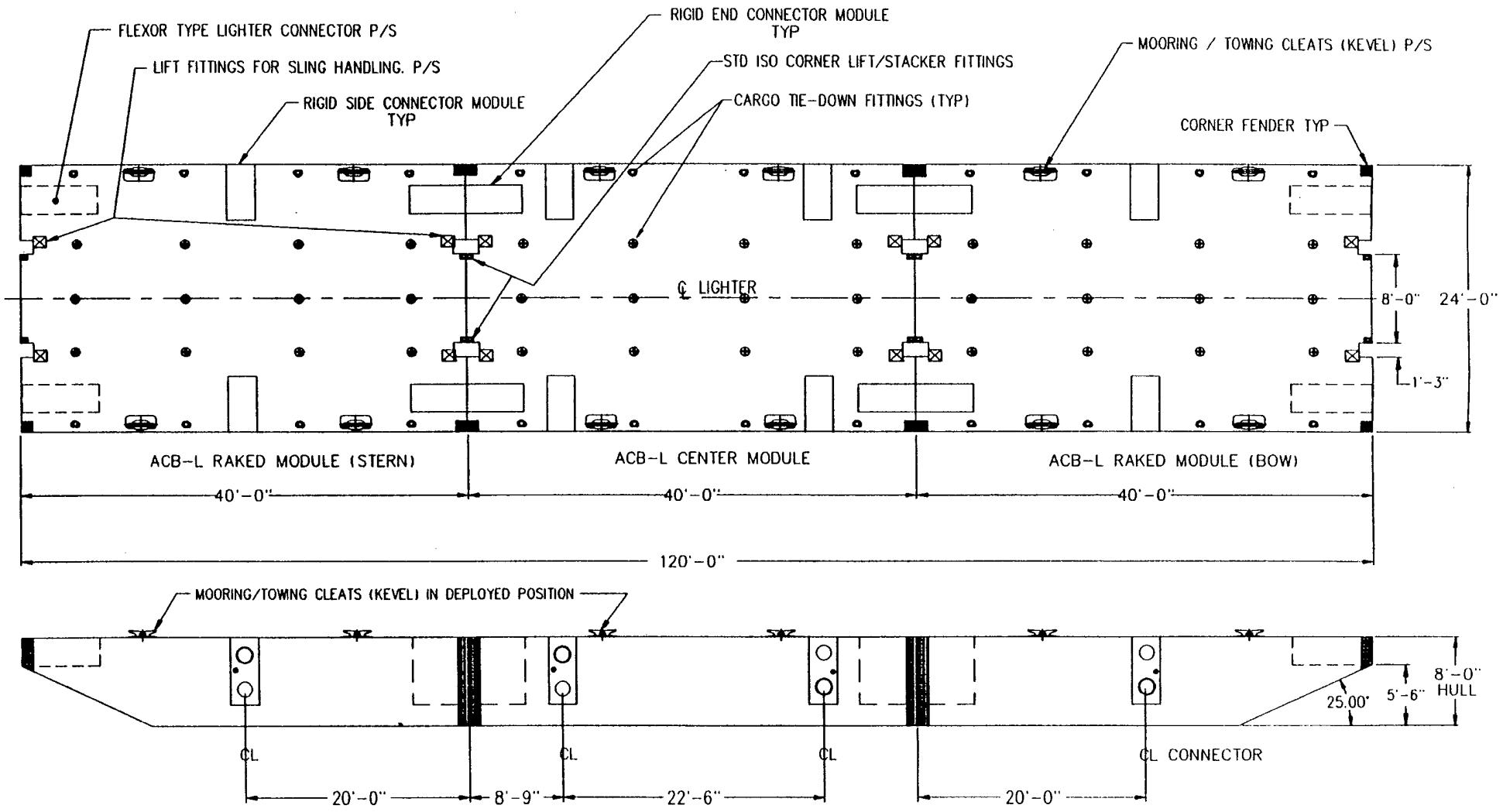
INITIAL ASSEMBLY OPERATION OF MODULES



FINAL ASSEMBLY OPERATION OF MODULES

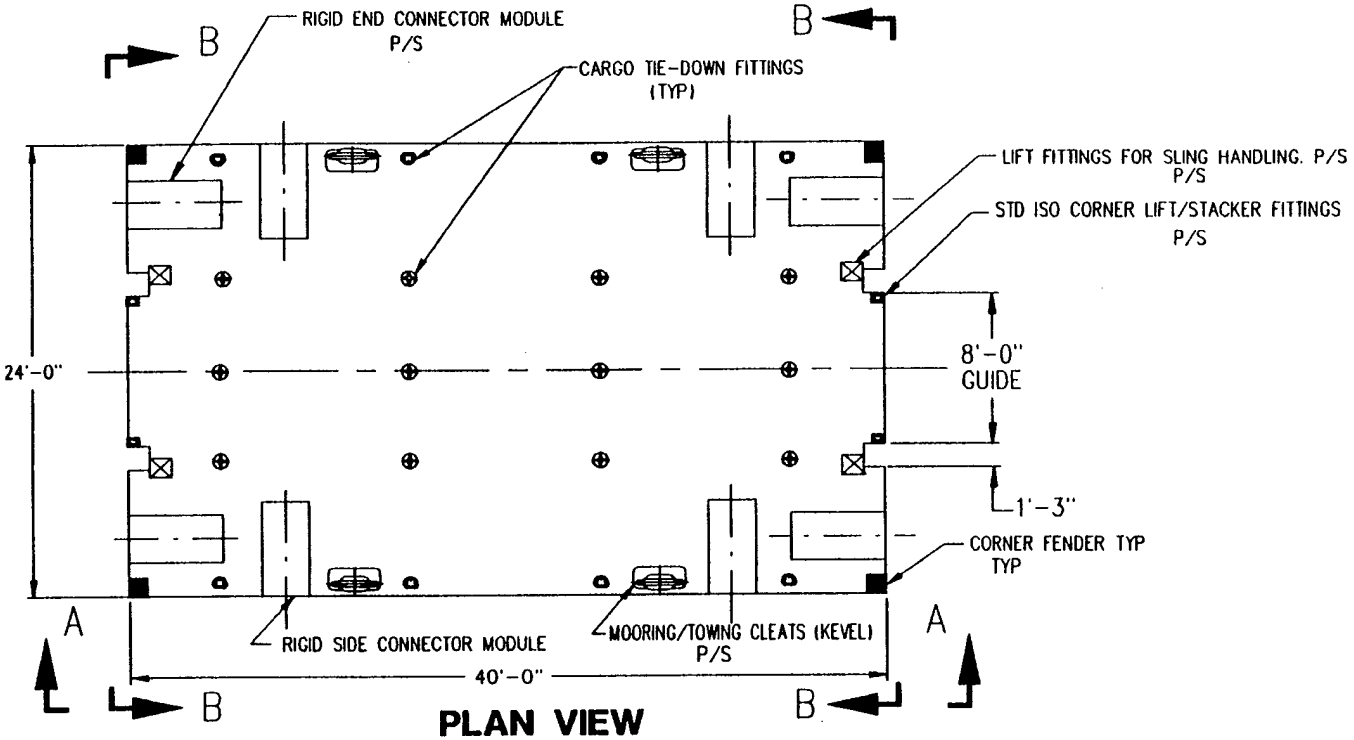
MOORING AND POSITIONING OF MODULES FOR ALONGSIDE ASSEMBLY

FIGURE 3-14

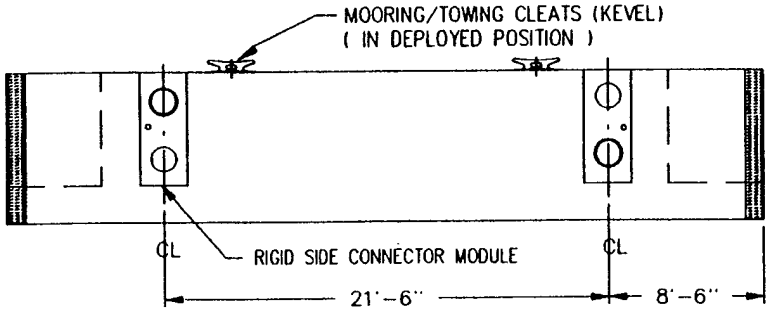


MODULAR ACB LIGHTER GENERAL ARRANGEMENT & KEY DIMENSIONS

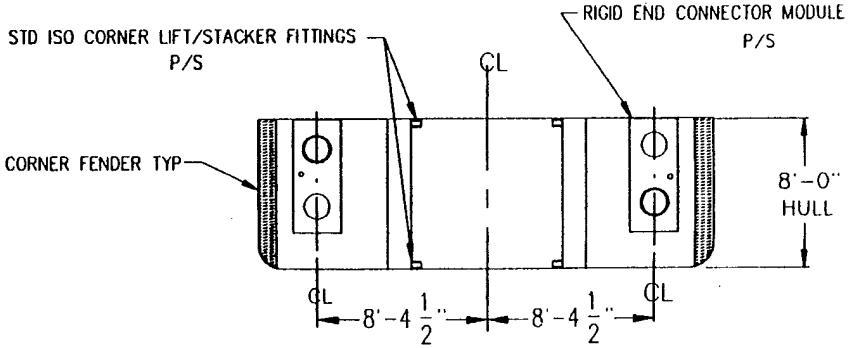
FIGURE 3-15



PLAN VIEW



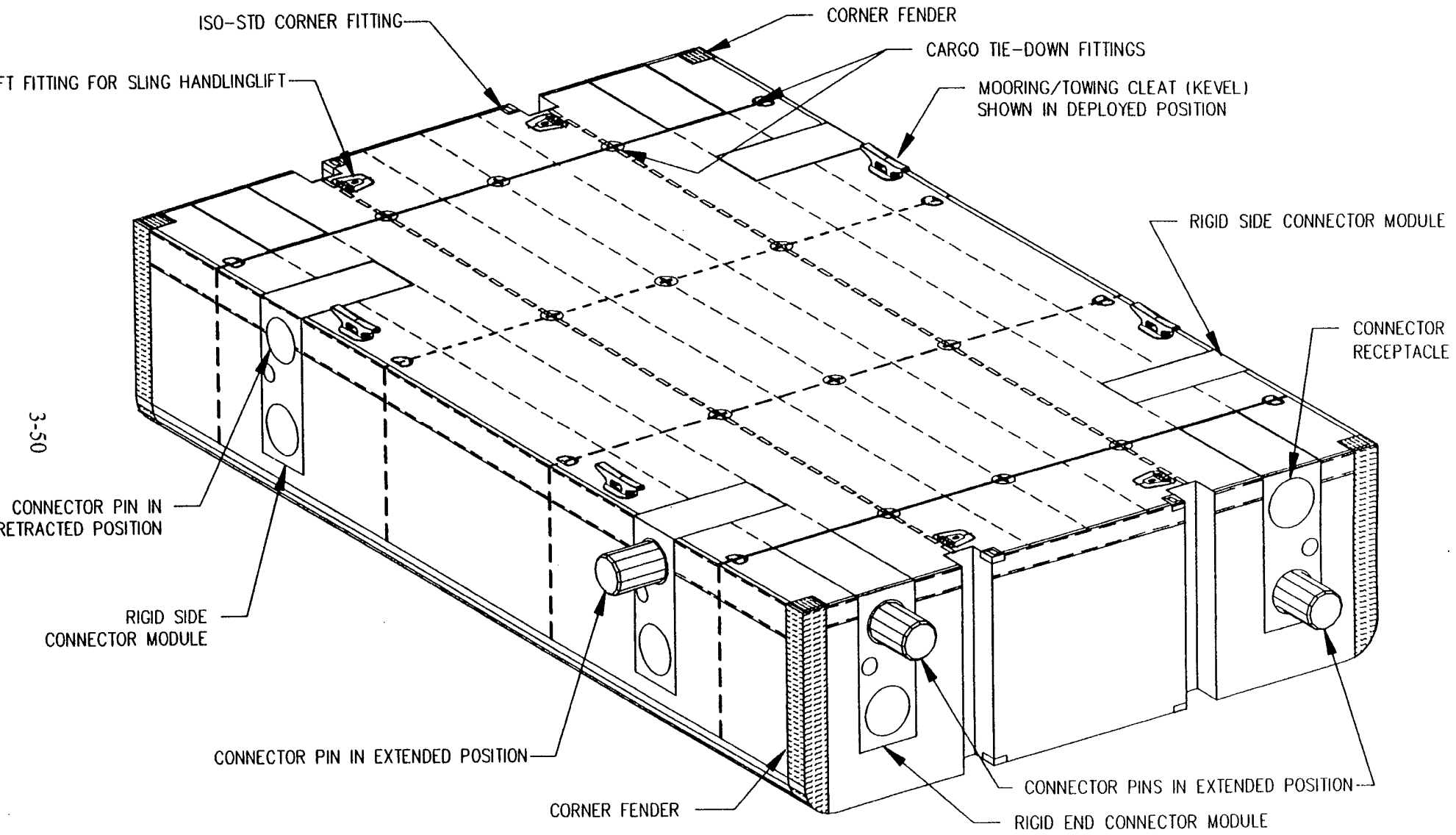
ELEV A-A



END VIEW B-B

ACB LIGHTER CENTER MODULE GENERAL ARRANGEMENT

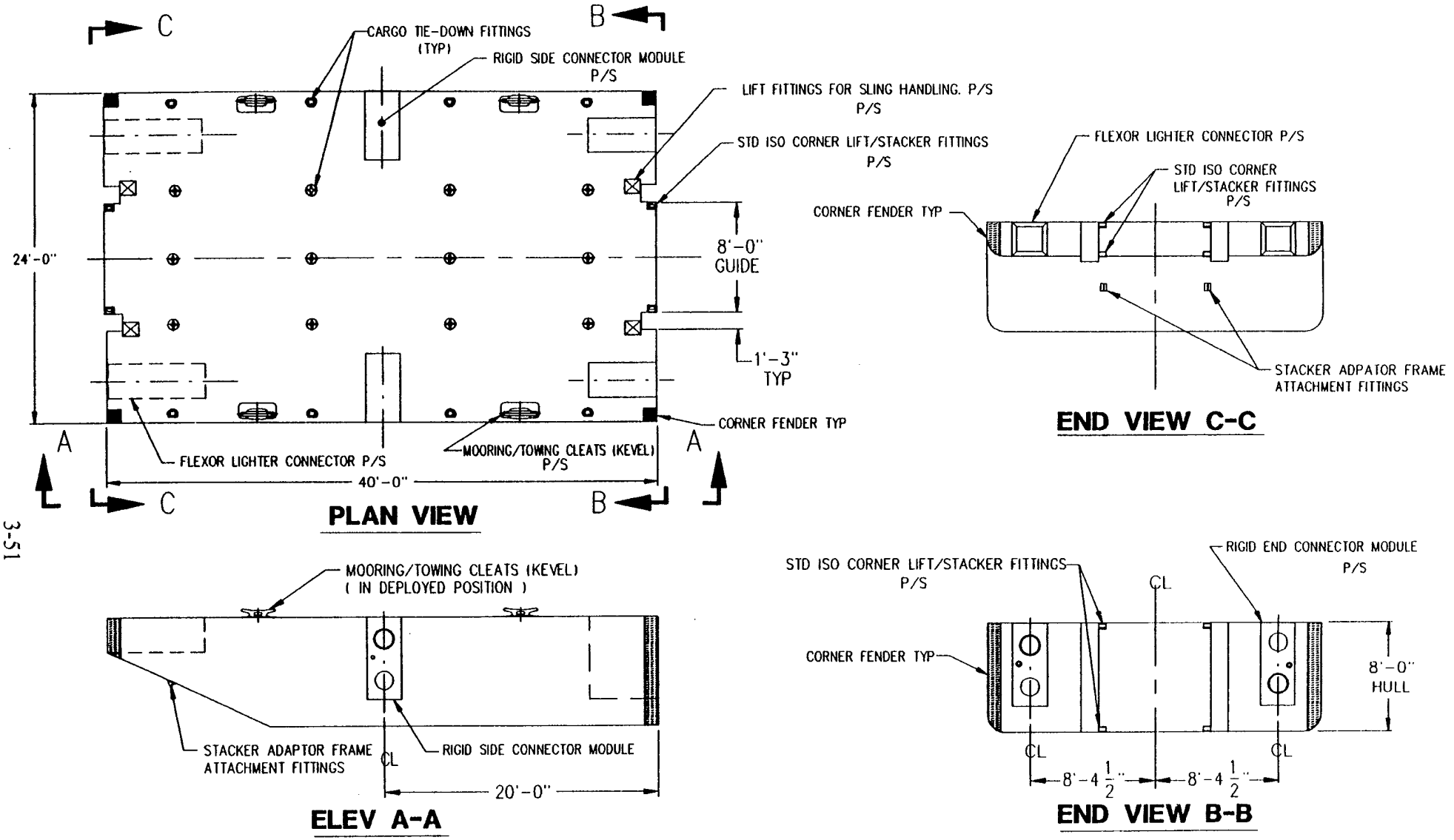
FIGURE 3-16



ACB-LIGHTER CENTER MODULE

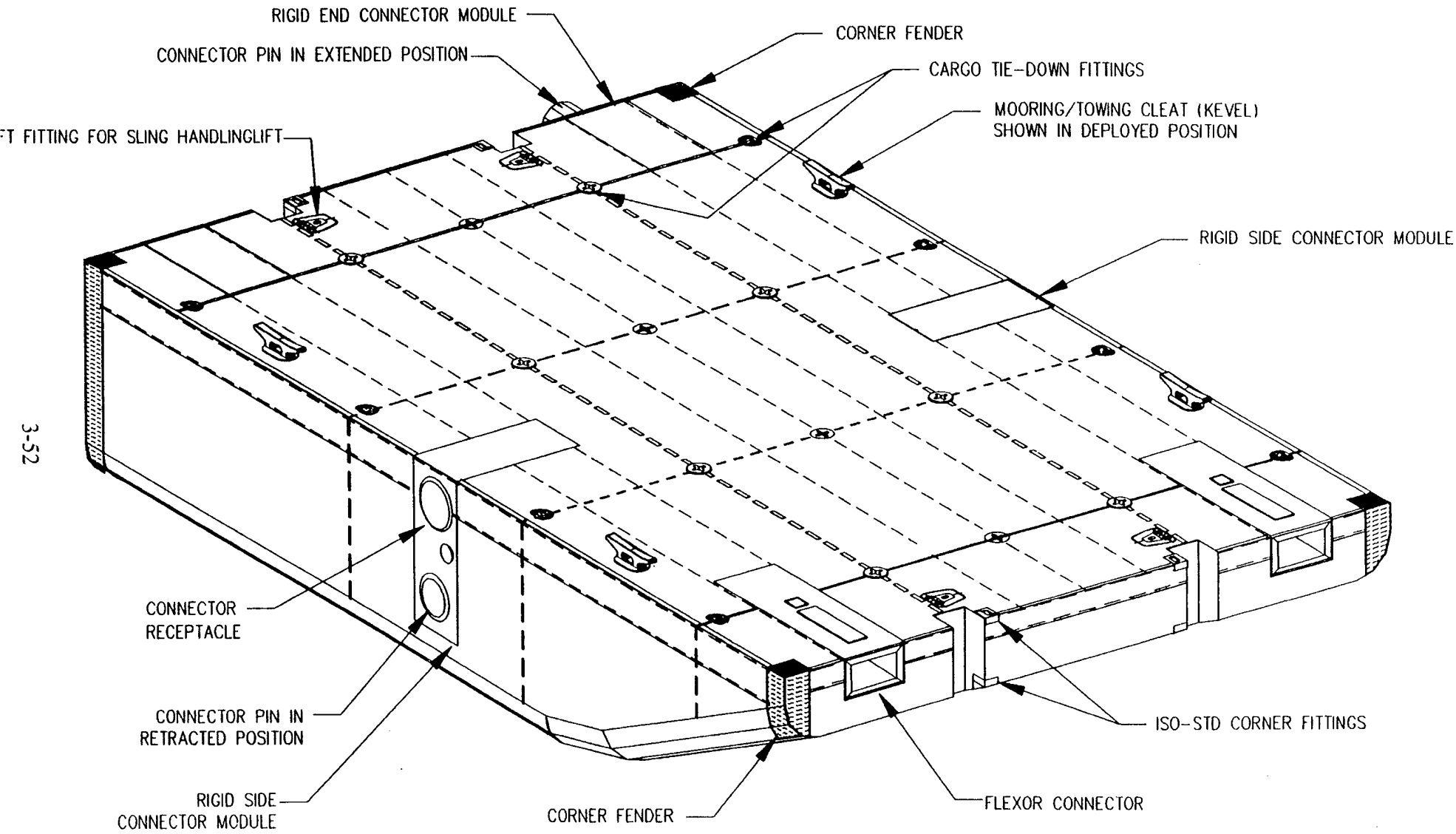
(24 FT W X 40 FT L X 8 FT D)
ISOMETRIC VIEW

FIGURE 3-17



ACB LIGHTER RAKED (BOW/STERN) MODULE GENERAL ARRANGEMENT

FIGURE 3-18

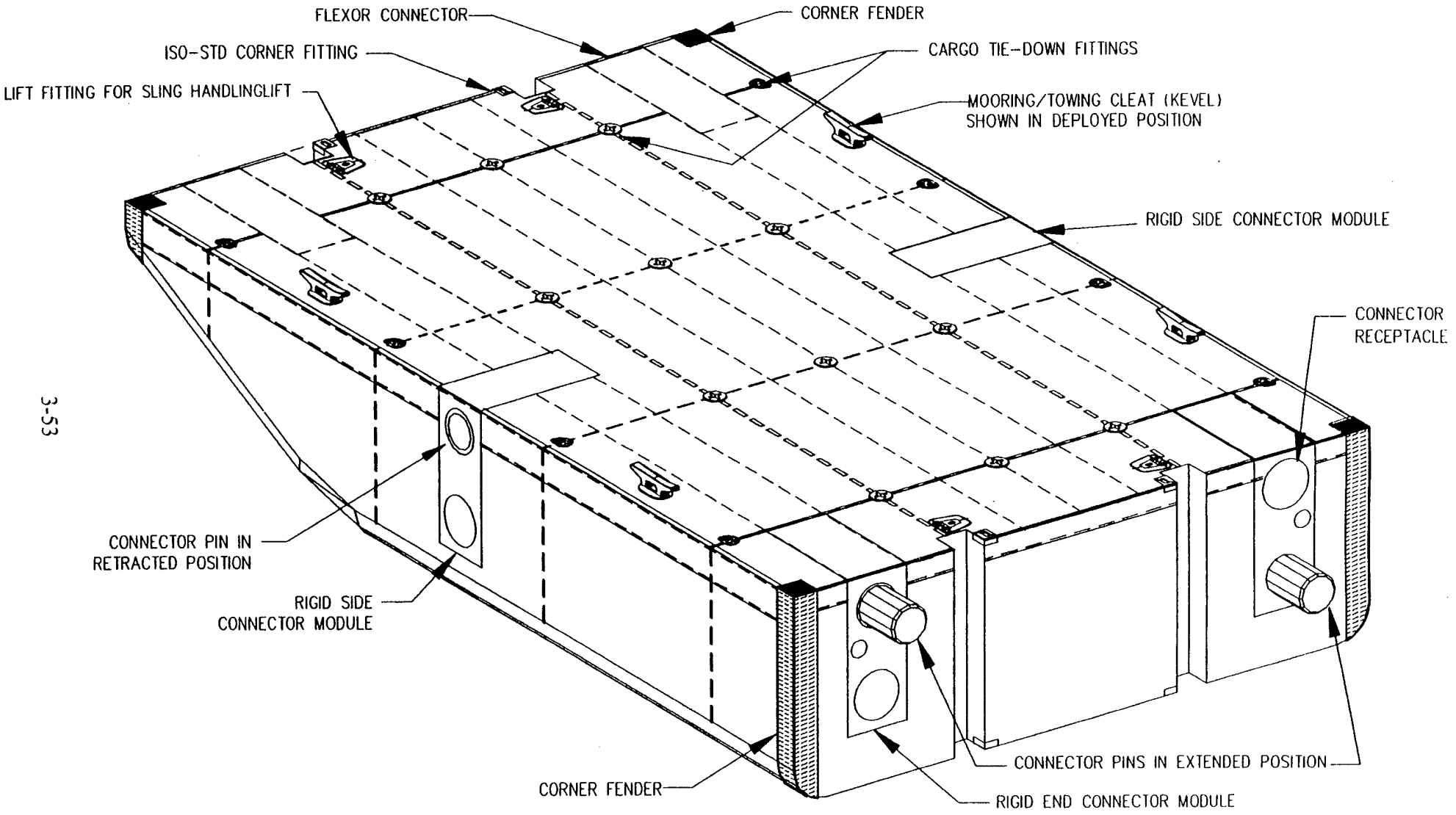


ACB-LIGHTER RAKED (BOW/STERN) MODULE

(24 FT W X 40 FT L X 8 FT D)

ISOMETRIC VIEW AT RAKED END

FIGURE 3-19



ACB-LIGHTER RAKED (BOW/STERN) MODULE

(24 FT W X 40 FT L X 8 FT D)

ISOMETRIC VIEW AT RIGID CONNECTION END

FIGURE 3-20

4.0 CONTAINER HOLD/CELL GUIDE INTERFACE REQUIREMENTS

One of the basic objectives of the ACB Lighter concept is to increase the transportability options of the lighter modules by making the modules suitable for insertion and stacking in 40 foot container holds of container ships and Navy transport ships such as the Auxiliary Crane Ship (T-ACS). This capability makes the transportation of modules possible in large numbers inside container holds, where the modules would be stacked in lighter sets.

Cargo holds, suitable for transportation of the ACB lighter modules, must meet the requirements defined in Section 4.1. The ACB lighter modules must also incorporate some of the necessary ISO requirements of standard 40 foot cargo containers for container hold/guide interface. The module container guide interface requirements are discussed in Section 4-2. The stacking options of modules in container guides are discussed in Section 4.3.

4.1 Cargo Hold and Cell Guide Requirements

The cargo hold of a transport ship must meet the following requirements for stacking and transporting the 24 foot wide by 40 foot long by 8 foot deep lighter modules.

a. The container hold must be equipped with fixed cell guides suitable for the transportation of standard 40 foot ISO container.

b. The hold must have a minimum of three adjacent container cells to accommodate the 24 foot wide modules.

c. The ACB Lighter modules are supported, similarly to a standard 40 ft ISO container, at the four tank top container support points of the center container cell. Ideally, for maximum utilization of the available stacking height, the three adjacent container cells should have the same depth as shown in Figure 4-2. However, some differences in cell depth can be eliminated by either using a flatrack or an ISO container as a base on the bottom of the center cell.

d. The required container cell depth (measured form the underside of the hatch cover structure to the top surface at the container support pads at the bottom of the cell guides) must be at least 8'-9", 17'-0", 25'-3", 30'-6", 41'-9" or 50'-0" to accommodate a stack of 1, 2, 3, 4, 5 or a maximum of 6 ACB lighter modules respectively. The minimum required cell depths were calculated with an 8'-3" stacking height for each module (see Figure 4-2 for Option B) and a 6 inch clearance allowance between the underside of the hatch cover structure and the top of the upper most module in the stack.

4.2 ACB Module Interface Requirements

The standard container cell guide, face to face, inside width is 8'-1" as indicated in center guide section of each module is 8'-0" wide the same as the width of a standard ISO container. The guide section will provide guidance for the modules during loading the modules into the cell guides. The distance between two adjacent container cells is non-standard and varies from ship to ship.

Planviews A and B of Figure 4-1 shows the anticipated minimum and maximum distances for adjacent cell guides. The module structure adjacent to the 8'-0" wide guide surface of the module, is provided with an 1'-3" wide by 1'-0" deep notch as shown, to clear the outboard cell guides.

4.3 Stacking of Modules in Cell Guides

As shown in Figure 4-2, the ACB lighter modules will be stacked in 40 foot container guides. Two sets of lighter modules one shown for 8'-1" (Option A) and 8'-3" (Option B) module stacking heights. The stack of modules are supported at the four (4) container support points of the center container cell, similarly to supporting a six high stack of 40 foot ISO containers.

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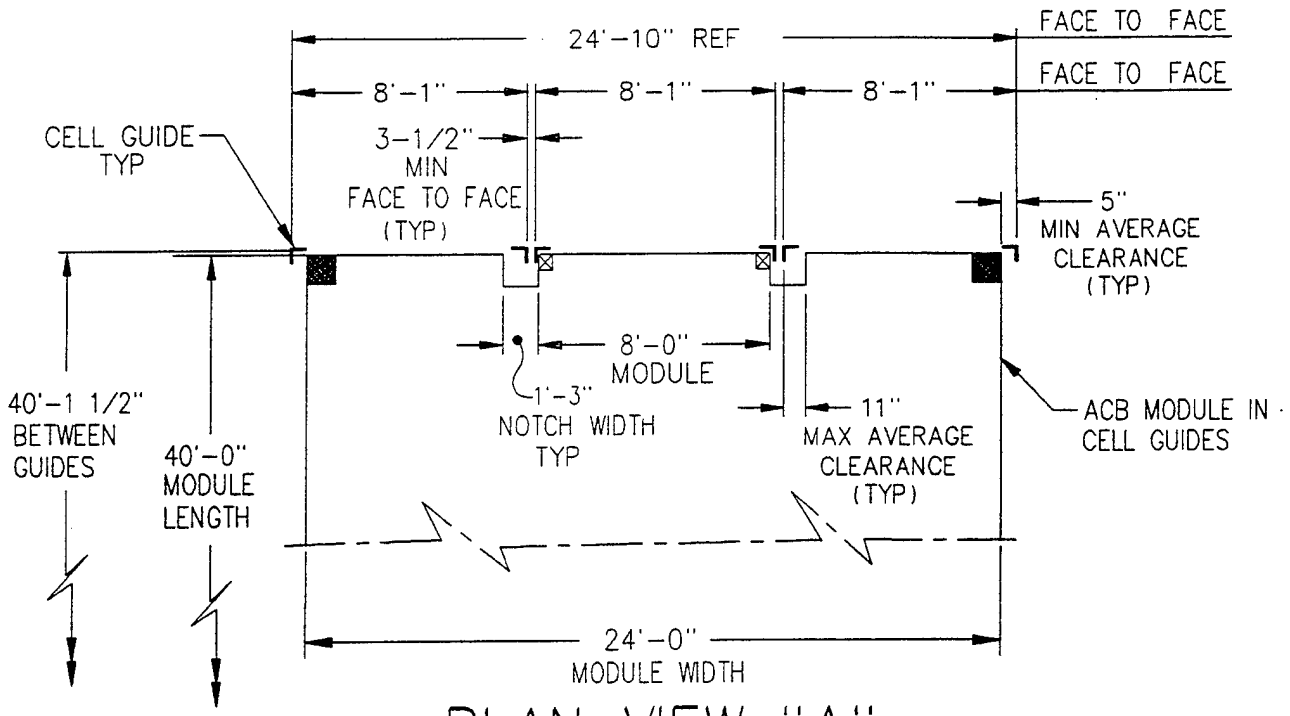
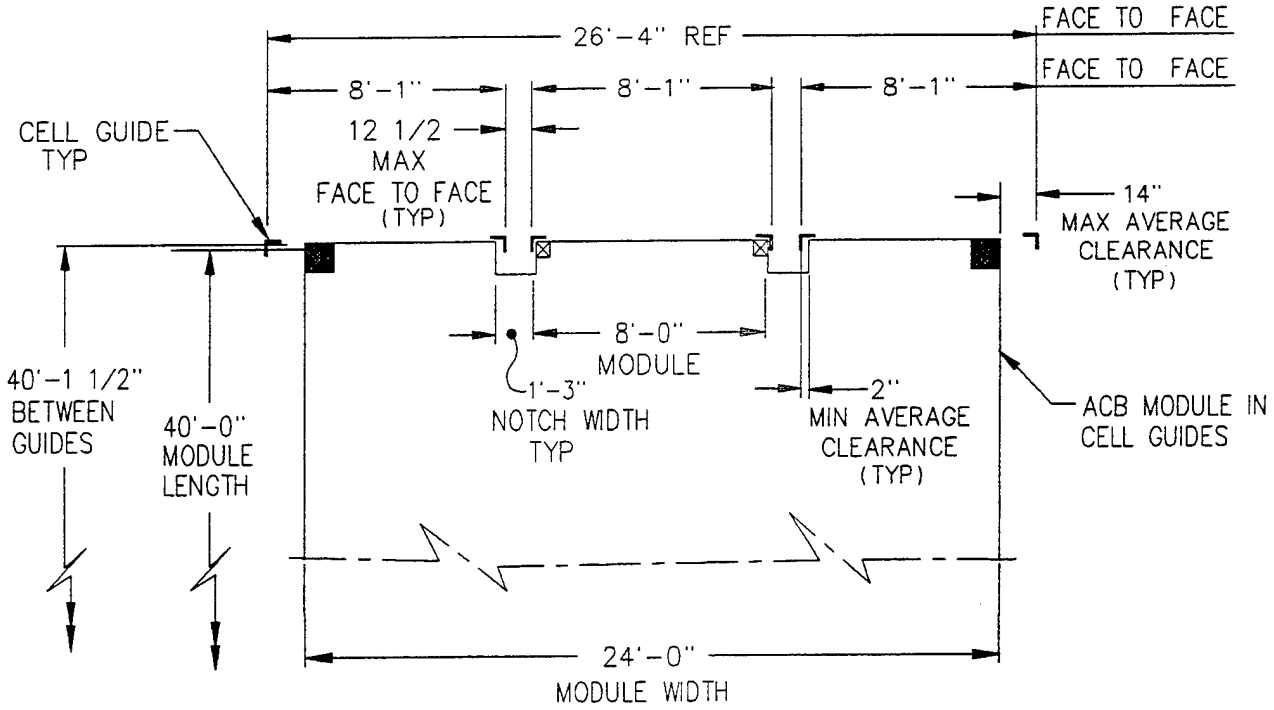


PLAN VIEW "A"

MIN CONTAINER CELL GUIDE SPACINGS & CLEARANCES

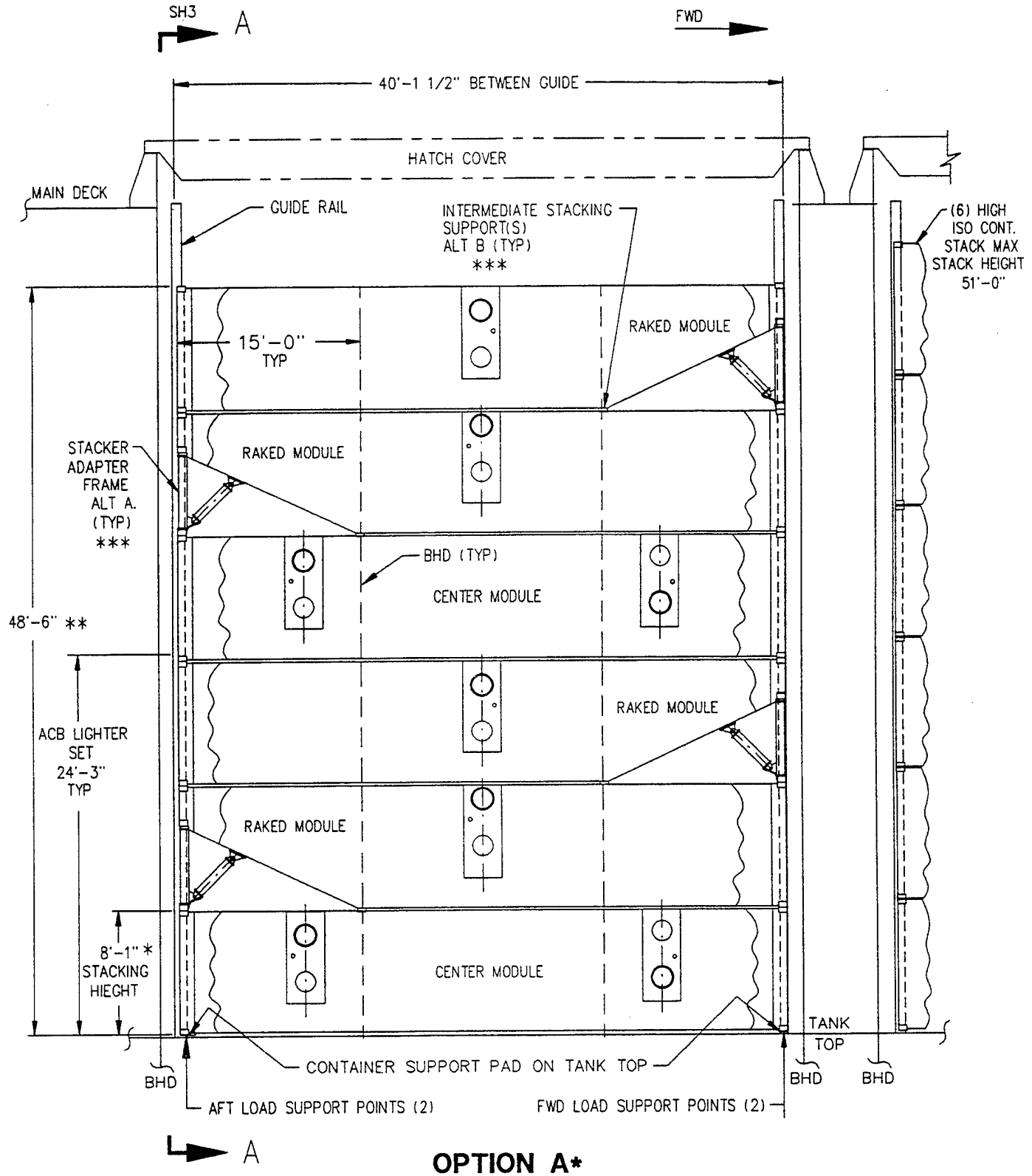


PLAN VIEW "B"

MAX CONTAINER CELL GUIDE SPACINGS & CLEARANCES

ACB LIGHTER MODULE & CELL GUIDE INTERFACE

FIGURE 4-1



OPTION A*

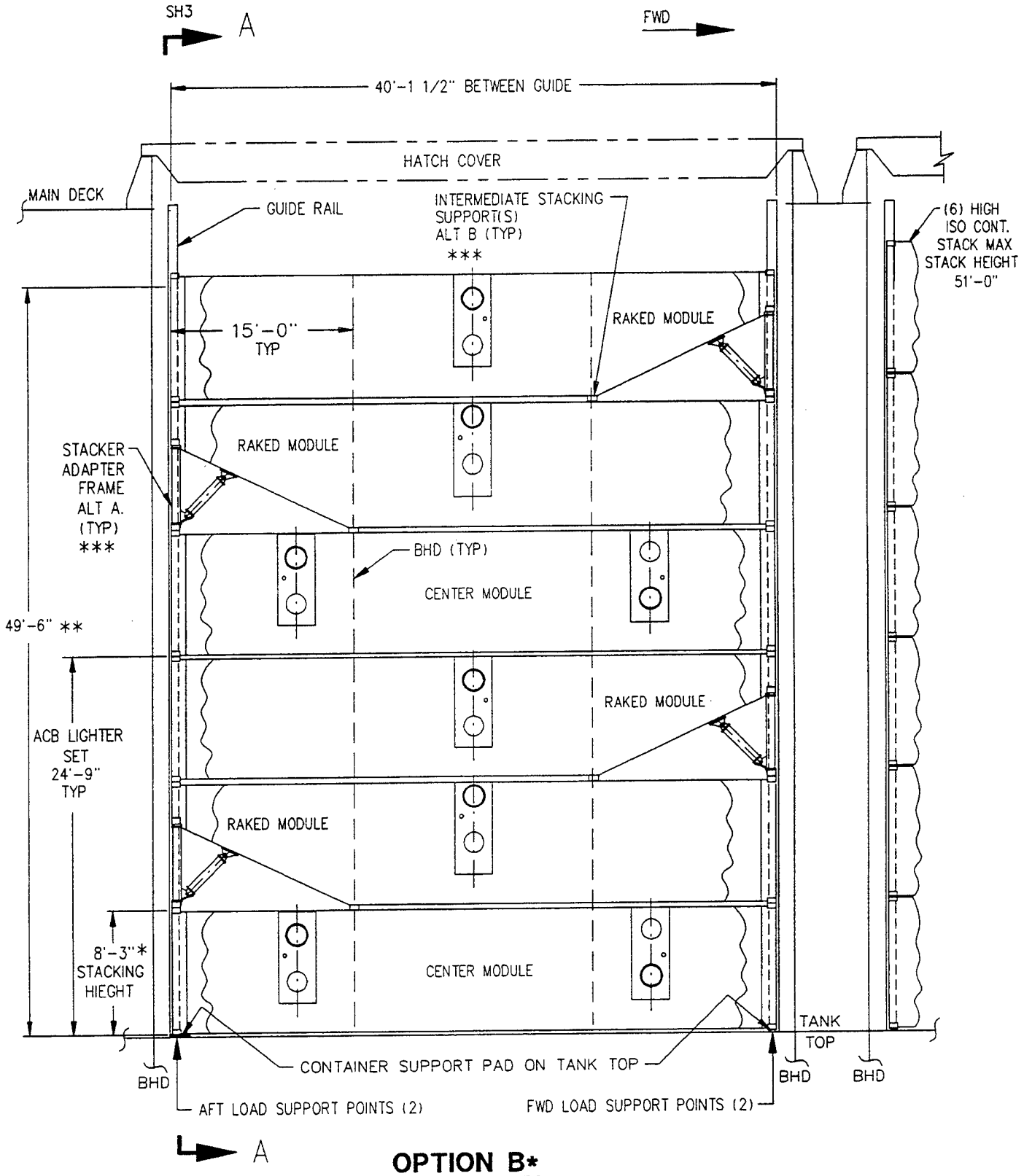
ACB LIGHTER MODULES STACKED IN 40 FT CELL GUIDES

* MODULE STACKING HEIGHT (8'-1") WITH FLUSH TYPE CARGO TIE-DOWN FITTING ON MODULE DECK. (OPTION A)

** (6) HIGH MAXIMUM MODULE STACK (2 ACB LIGHTERS).

*** SEE SECTION 3.2.2.2

FIGURE 4-2
(1 OF 3)



OPTION B*

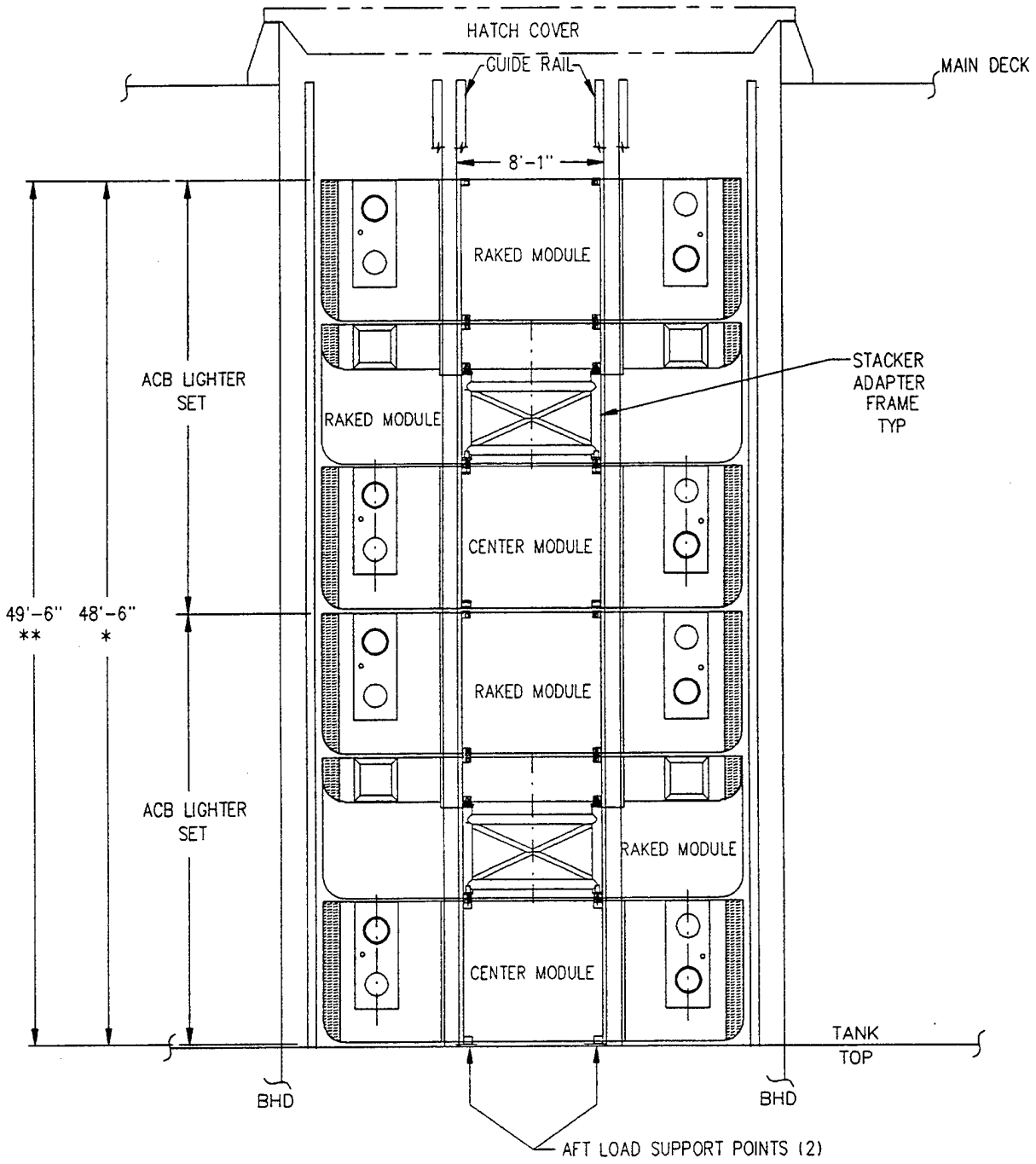
ACB LIGHTER MODULES STACKED IN 40 FT CELL GUIDES

* MODULE STACKING HEIGHT (8'-3") WITH RAISED TYPE CARGO TIE-DOWN FITTING ON MODULE DECK. (OPTION B)

** (6) HIGH MAXIMUM MODULE STACK (2 ACB LIGHTERS).

*** SEE SECTION 3.2.2.2

FIGURE 4-2
(2 OF 3)



SECT A-A

LKG FWD

ACB LIGHTER MODULES STACKED IN 40 FT CELL GUIDES

FIGURE 4-2
(3 OF 3)

5.0 HANDLING

The ACB Lighter Modules are outfitted with two independent sets of top side handling fittings. The primary set of top side handling fittings are standard ISO corner fittings (Figure 3-3) installed in accordance with ISO STD 668. The corner fittings can be used to lift the modules with the following equipment:

a. 40 ft container spreaders with automatic twist locks used in container terminals for handling standard ISO containers.

b. 40 ft spreaders with manually operated twist locks and four point lifting bridle for lifting by boom type heavy lift cranes similar to the cranes of the T-ACS (see Figures 5-1 and 5-2).

A secondary set of four (4) hinged lifting pads (Figure 3-6) are also provided on the top side of each ACB Lighter modules as shown in Figures 3-16 and 3-19. The hinged lifting pads would be utilized for handling with a 40 ft container sling (see Figures 5-3 and 5-4) for the following handling scenarios:

a. When damage to the ISO container fittings prevents handling of the modules using standard 40 ft container spreaders.

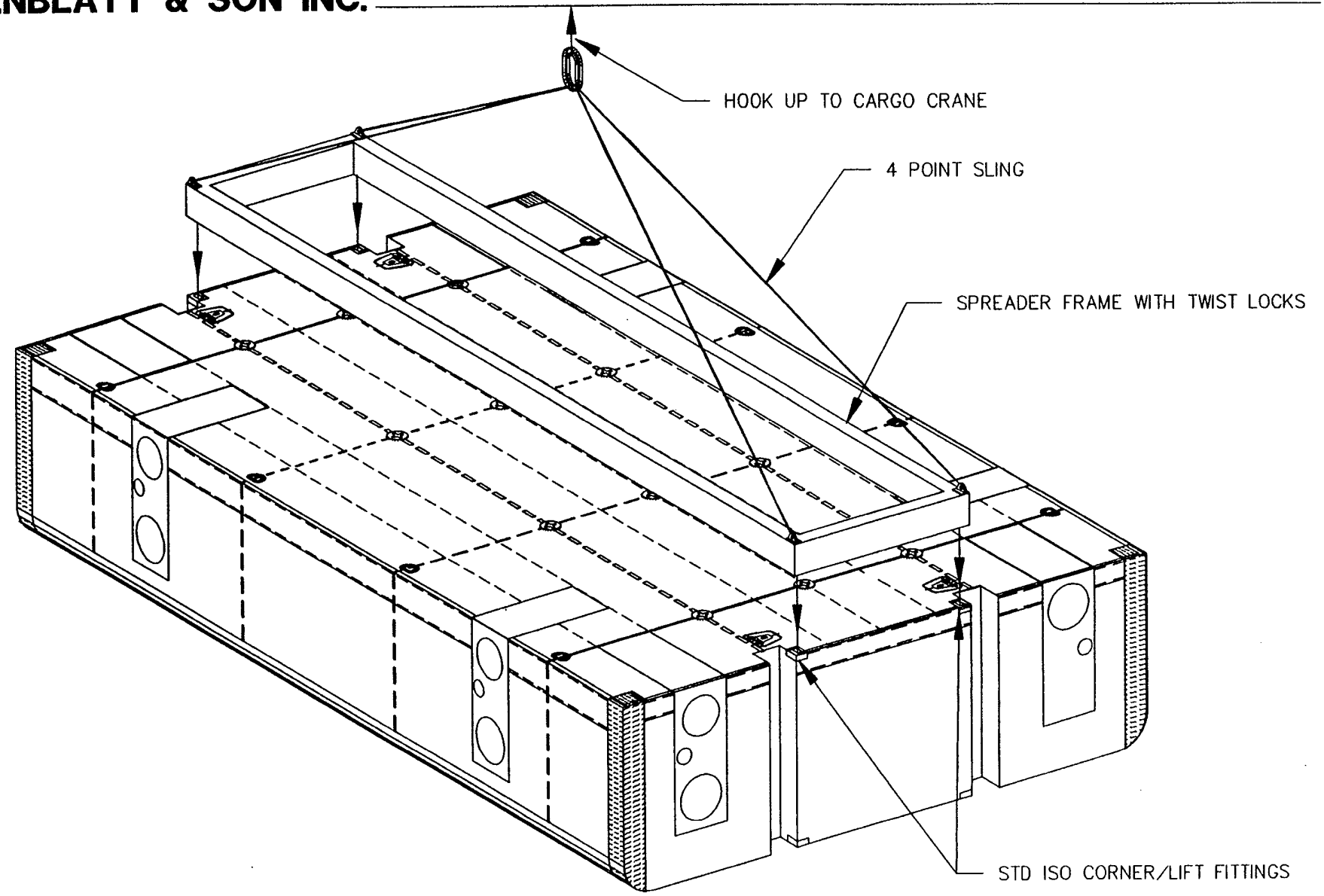
b. During offloading of the modules from the container holds into the water, using the heavy lift crane(s) of the T-ACS. Using container spreaders for this handling scenario would be dangerous to personnel and the release of the spreader twist locks may not be possible under Sea State 3 shipmotion conditions.

The four (4) bottom ISO corner fittings (Figure 3-4) will allow the loading of the module on standard 40 ft container trailers or chassis for inside terminal transportation. The modules will be secured by the four (4) twist locks on the trailer frame engaging the bottom container fittings on the module.

The above described handling scenarios are valid only for handling lighter modules whose gross weight is equal or less than 67,200 lbs the maximum allowable weight for a standard 40 ft ISO container.

Despite considerable progress made in developing the preliminary structural design criteria for the ACB lighter modules, this first phase development effort could not achieve the 67,200 lbs maximum allowable weight limit for the lighter module(s). As shown in Tables 3-7.1 and 3-7.2 the total estimated module weights (scantling and fittings) are 87,975 and 75,031 lbs for the center and raked ACB lighter modules respectively. Therefore, the estimated center and raked module weights exceed the 67,200 lbs allowable weight limit by 20,775 lbs and 7,831 lbs respectively.

While the above weight results appear to be highly unfavorable and would tend to eliminate the possibility of utilizing existing standard container cranes, spreads and container trailers for module handling. MR&S believes that a future second phase development effort which would develop and implement the recommended action items for weight reduction would bring the module weights down to the maximum allowable limit of 67,200 lbs. (See section 8.0 for recommendations on weight reductions).

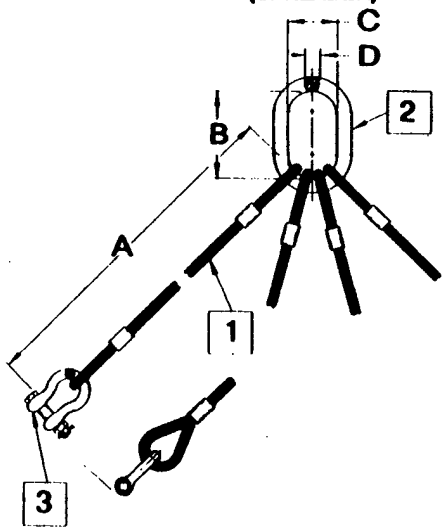


ACB-LIGHTER CENTER MODULE HANDLING WITH 40 FT STD CONTAINER SPREADER ISOMETRIC VIEW

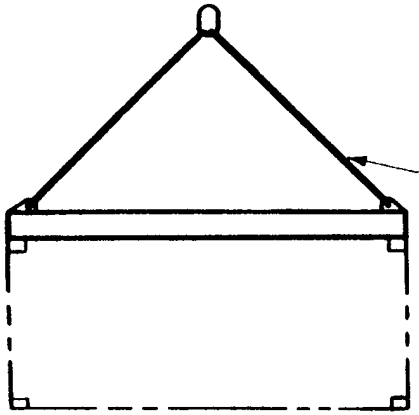
FIGURE 5-1

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

SLG109
SLING, MULTIPLE LEG
(SPREADER)



MODEL NO.	DIM	A	B	C	D	WT KGS. (LBS.)
SLG109-1	MM	2963.9	406.4	203.2	57.1	
	(INCH)	(116.7)	(16.0)	(8.00)	(2.25)	



APPLICATION

SPECIFICATIONS

MATERIAL:
ALL CONSTRUCTION IS PER BEST COMMERCIAL QUALITY. SEE CHART BELOW FOR SPECIFIC MATERIAL.

STRENGTH:
74,700 LBS. SAFE WORKING LOAD

TESTING:
ASSEMBLY IS PROOF TESTED TO 145,000 LBS.

FINISH:
ALL SURFACE FINISHES PROVIDE GOOD CORROSION PROTECTION. SEE CHART BELOW FOR SPECIFIC FINISH.

ITEM NO	PART NO	PART NAME	DESCRIPTION
3	-	SHACKLE	STEEL, PAINTED
2	-	LIFTING RING	STEEL, ZINC PLT.
1	-	WIRE ROPE, 1-3/8" DIA.	STEEL

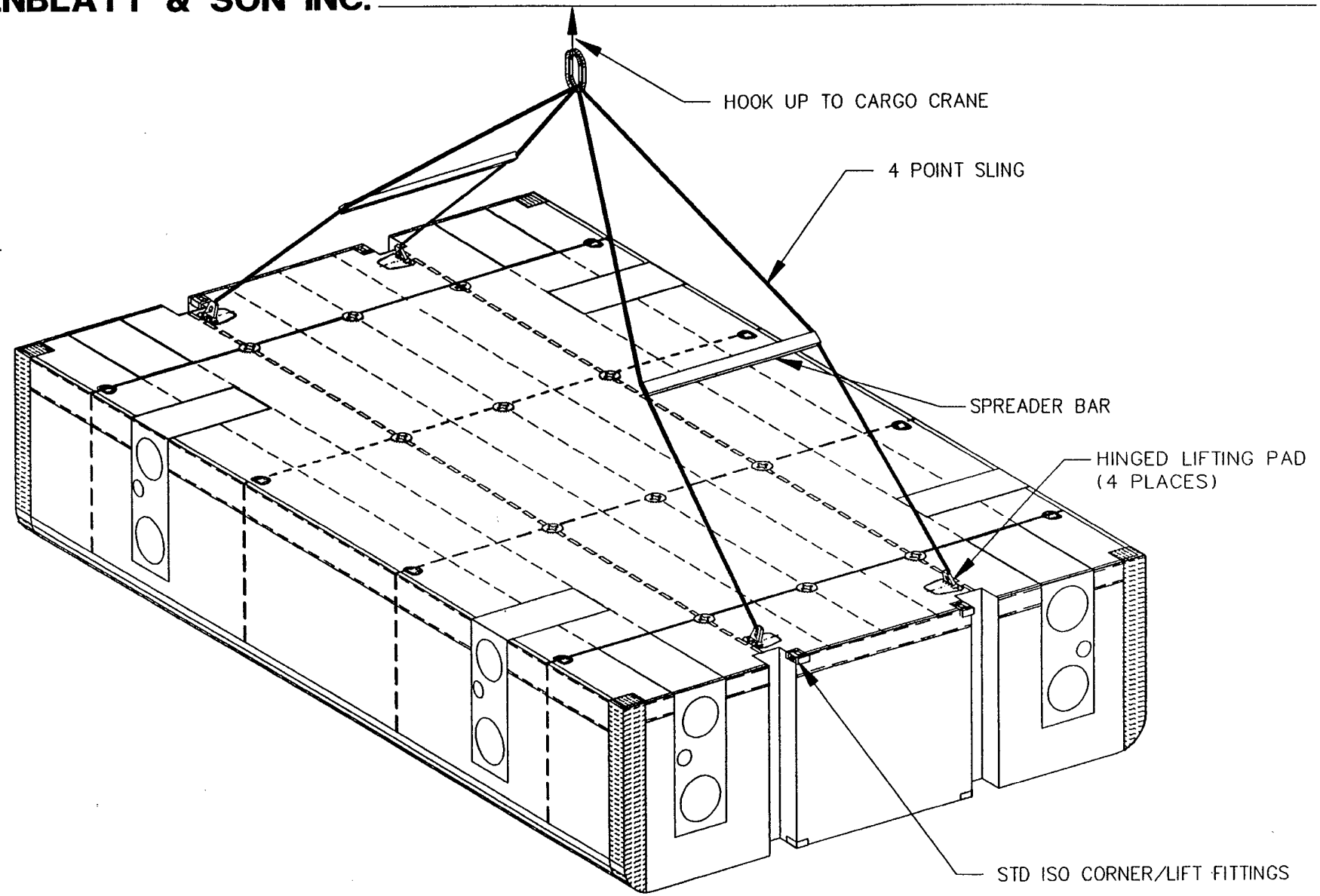
LIST OF MAJOR COMPONENTS

SLG109
SLING, MULTIPLE LEG
(SPREADER)

PECK & HALE, INC.
100 DIVISION AVENUE
WEST BABYLON, N.Y. 11795 USA

FSCM NO:84858	DRN: S.M.	SHEET OF	
DATE: 10/24/91	APPD: S.J.	2587 DWG NO	REV
SCALE: NONE	Q.C.:		

FIGURE 5-2



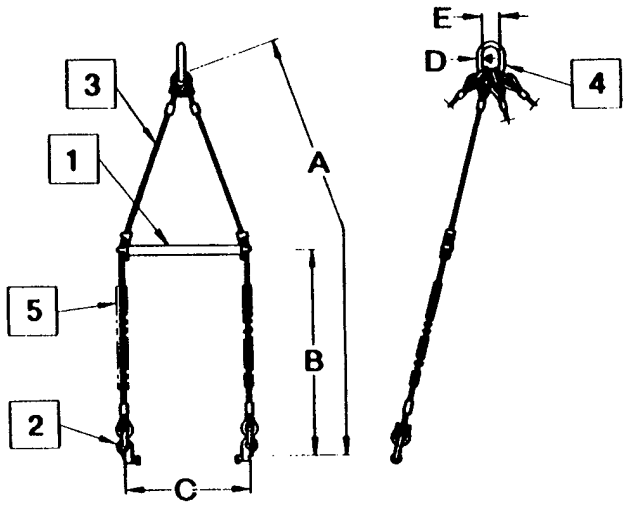
ACB-LIGHTER CENTER MODULE HANDLING
WITH STD 40 FT CONTAINER SLING
ISOMETRIC VIEW

FIGURE 5-3

NEXT ASSEMBLY

ISSUE	REVISION RECORD	DATE	APPD

SLG110
SLING, HOISTING
(40' CONTAINER)



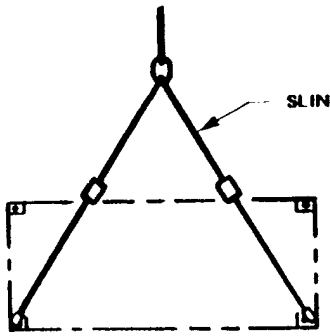
MODEL NO.	DIM	A	B	C	D	E	WT KGS. (LBS.)
SLG110-1	MM	8636.0	3987.8	2743.2	50.8	177.8	
	(INCH)	(340.0)	(157.0)	(108.0)	(2.00)	(7.00)	

SPECIFICATIONS

MATERIAL:
ALL CONSTRUCTION IS PER BEST COMMERCIAL QUALITY. SEE CHART BELOW FOR SPECIFIC MATERIAL.

STRENGTH:
40 TONNES SAFE WORKING LOAD

FINISH:
ALL SURFACE FINISHES PROVIDE GOOD CORROSION PROTECTION. SEE CHART BELOW FOR SPECIFIC FINISH.



APPLICATION

ITEM NO	PART NO	PART NAME	DESCRIPTION
5	-	TUBING	PLASTIC
4	-	LINK	STEEL, GALV
3	-	WIRE ROPE, 1-1/4" DIA.	STEEL, GALV
2	MK5	CAMLOCK	STEEL, PAINTED
1	PH3021-22	SPREADER BAR	STEEL, PAINT

LIST OF MAJOR COMPONENTS

SLG110
SLING, HOISTING
(40' CONTAINER)

Peck & Hale
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:84858	DRN: S M	SHEET OF	
DATE: 10/24/91	APPD: S J	4090 DWG NO	REV
SCALE: NONE	Q.C.:		

FIGURE 5-4

6.0 PRELIMINARY TRIM AND STABILITY

A concept level study was conducted to examine the basic trim and intact stability characteristics of the ACB modules and assembled lighter. First, the floating draft and trim of the lightship raked (end) and center modules, and the assembled lighter were determined. Next, the amount of deck load necessary to achieve level trim at equal draft for the modules, prior to assembly was calculated. Finally, for the assembled lighter, the intact stability was checked with a full load of containers, and compared to the USCG ocean and U.S. Navy coastal requirements. All hydrostatic and stability characteristics were produced by the HECSALV PC computer program, Reference (9).

6.1 The Lightship Floating Draft and Trim of the Modules and Assembled Lighter

The hull geometries for the raked and center modules, and the assembled lighter were entered into HECSALV. Using the hull geometries, hydrostatic properties were calculated by the program at various drafts. A table of hydrostatics and the curves of form are presented in Table 6-1 and Figure 6-1 for the assembled lighter.

The lightship weight estimates for the raked and center modules, and for the assembled ACB Lighter, which include structure, rigid and flexible connectors, deck fittings, welding, mill tolerance and paint, are given in Tables 3-7.2 and 3-7.1 and Table 3-7. To these amounts, a 3% weight margin has been added to account for the inherent limits in precision of the initial estimate. The vertical and longitudinal centers of gravity were also estimated. Floating trim and stability summaries based upon these weights and centers of gravity are shown in Tables 6-2 and 6-3. As indicated, the draft for the raked module is 1.68 feet with a trim of 2.44 feet and the draft of the center module is 1.50 feet. The draft of the assembled lighter is 1.61 feet, as shown on Table 6-4. A curve of statical stability for the assembled lighter in the lightship condition is presented in Figure 6-2.

6.2 Deck Load Necessary to Achieve Level Trim at Equal Draft for the Modules

The amount of deck load necessary to level the raked modules and then achieve the same draft, 2.01 feet, on the center module is shown in the Trim and Stability Summaries on Tables 6-5 and 6-6. The required deck loads for the raked module is 7.40 L.Tons or 1937 gallons of sea water, placed at the inboard (8 foot) end. For the center module, 14.25 L.Tons or 3732 gallons of sea water is necessary, centrally located. The deck loads could be accomplished by using portable bladders filled with sea water, which would be drained and removed after the lighter is assembled.

6.3 Intact Stability of the Assembled Lighter with a Full Load of Containers

An investigation of the intact stability was conducted for the assembled lighter with a full load of containers. 13 ISO-1CC (20 ft) containers, having an average weight of 20 L.Tons each, were loaded onto the deck. This represents the possible extreme loading condition. The Trim and Stability Summary for this full load condition is shown in Table 6-7, with the statical stability curve given in Figure 6-3.

The intact stability at this loading condition was compared to the USCG wind heel and U.S. Navy combined wind and rolling requirements, References (2) and (3). The USCG windheel criteria was calculated for ocean service, and indicates an angle of heel of 2.6 degrees compared to a permissible angle of heel of 7.1 degrees, as shown in Tables 6-8 and 6-9 and Figure 6-4.

Using the U.S. Navy's criteria for coastal service, the lighter would heel to an initial angle of 2.9 degrees under the influence of a 60 knot wind, as shown in Figure 6-5. The righting arm at this heel, 0.154 feet, must be no greater than the maximum righting arm, 0.896 feet. This criteria also takes into account a storm sea condition by assuming extreme rolling to 25 degrees. The righting area A1, which is a measure of the righting energy, must be not less than 1.40 times the area A2 for the vessel rolling 25 degrees to windward. Although the loaded lighter does not meet this requirement, 13.69 ft-deg versus 22.12 ft-deg required, the buoyancy of the containers were not taken into account. If the containers were securely tied down, the righting arm curve would be extended and the righting area would probably be sufficiently increased.

An estimate of the lighter's natural period of roll was found to be 6.45 seconds in the full load condition. On comparing this with the period of maximum energy of Sea State 3, 6.5 seconds from Reference (4), it can be assumed that vessel may exhibit such angles of roll as in the U.S. Navy's criteria in beam seas, but this would have to be confirmed by a seakeeping analysis (see Section 8.2.3).

The results of this stability analysis indicate the lighter meets USCG standards for ships in ocean service and thereby would appear to have more than adequate stability as it more appropriately represents a barge in coastal service. The failure to meet the Navy intact criteria must be considered in light of the fact that this criteria is intended for coastwide vessels at sea in up to sea state 5 or 6, which is not the case for the lighter which will operate in at most in sea state 3 in semi-protected water.

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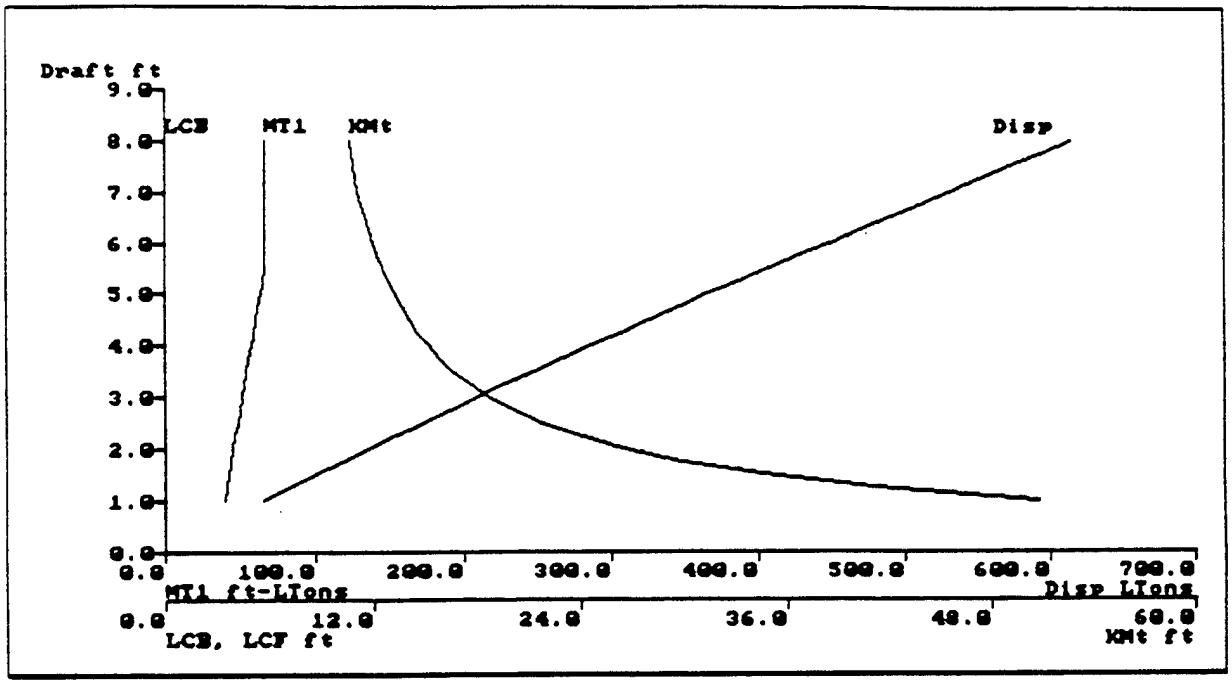
TABLE 6-1

HYDROSTATIC TABLES
ACB LIGHTER
(24 FT W X 120 FT L X 8 FT D)

MLD. DRAFT (ft)	DISPL. (LT-SW)	KMt (ft)	LCB (ft-FP)	LCF (ft-FP)	MT1in (ft-LT/in)	TPI (LT/in)
1.000	65.76	50.809	60.000A	60.000A	40.599	5.75
1.250	83.21	41.077	60.000A	60.000A	41.994	5.82
1.500	100.85	34.506	60.000A	60.000A	43.352	5.88
1.750	118.68	29.873	60.000A	60.000A	44.720	5.95
2.000	136.69	26.437	60.000A	60.000A	46.094	6.01
2.250	154.89	23.793	60.000A	60.000A	47.472	6.07
2.500	173.27	21.707	60.000A	60.000A	48.869	6.12
2.750	191.84	20.026	60.000A	60.000A	50.288	6.18
3.000	210.58	18.649	60.000A	60.000A	51.727	6.24
3.250	229.49	17.503	60.000A	60.000A	53.189	6.30
3.500	248.56	16.562	60.000A	60.000A	54.745	6.36
3.750	267.83	15.792	60.000A	60.000A	56.444	6.43
4.000	287.23	15.140	60.000A	60.000A	58.187	6.49
4.250	306.90	14.559	60.000A	60.000A	59.875	6.55
4.500	326.75	14.044	60.000A	60.000A	61.529	6.61
4.750	346.77	13.594	60.000A	60.000A	63.191	6.67
5.000	366.98	13.202	60.000A	60.000A	64.878	6.73
5.250	387.37	12.859	60.000A	60.000A	66.589	6.79
5.500	407.94	12.560	60.000A	60.000A	68.325	6.85
5.750	428.57	12.226	60.000A	60.000A	68.325	6.85
6.000	449.23	11.948	60.000A	60.000A	68.442	6.85
6.250	469.89	11.700	60.000A	60.000A	68.510	6.85
6.500	490.56	11.480	60.000A	60.000A	68.547	6.86
6.750	511.23	11.285	60.000A	60.000A	68.559	6.86
7.000	531.90	11.113	60.000A	60.000A	68.559	6.86
7.250	552.57	10.964	60.000A	60.000A	68.559	6.86
7.500	573.24	10.835	60.000A	60.000A	68.559	6.86
7.750	593.91	10.723	60.000A	60.000A	68.559	6.86
8.000	614.58	10.627	60.000A	60.000A	68.559	6.86

Assumes: Sea Water at 35.0063 ft3/LT
Ship floating at even keel (no heel or trim)



CURVES OF FORM

FIGURE 6-1

TABLE 6-2

RAKED MODULE
TRIM & STABILITY SUMMARY
LIGHTSHIP TRIM

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	33.14	5.100	21.950A	0.000	
3% Wgt. Margin	0.99	5.100	21.950A	0.000	0.00
Misc. Weight	0.00	0.000	20.000A	0.000	0.00
TOTALS	34.13	5.100	21.950A	0.000	0.00

STABILITY CALCULATION

KMt	30.643	ft
VCG	5.100	ft
GMt	25.543	ft
F.S. Correction	0.000	ft
GMt Corrected	25.543	ft

TRIM CALCULATION

LCF Draft	1.683	ft
LCB (even keel)	25.01	ft-AFT
LCF	24.486	ft-AFT
MT1in	4	ft-LT/in
Trim	2.443	ft-FWD
List	0.00	deg

DRAFTS

F.P. 3ft- 2.13in (0.969m)
M.S. 1ft-11.48in (0.596m)
A.P. 0ft- 8.82in (0.224m)

TABLE 6-3

CENTER MODULE
TRIM & STABILITY SUMMARY
LIGHTSHIP T & S

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	39.27	4.840	20.000A	0.000	
3% Wgt. Margin	1.18	4.840	20.000A	0.000	0.00
Misc. Weight	0.00	0.000	20.000A	0.000	0.00
TOTALS	40.45	4.840	20.000A	0.000	0.00

STABILITY CALCULATION

KMt	33.479	ft
VCG	4.840	ft
GMt	28.639	ft
F.S. Correction	0.000	ft
GMt Corrected	28.639	ft

TRIM CALCULATION

LCF Draft	1.496	ft
LCB (even keel)	20.00	ft-AFT
LCF	20.000	ft-AFT
MT1in	8	ft-LT/in
Trim	0.000	ft
List	0.00	deg

DRAFTS

F.P. 1ft- 5.95in (0.456m)
M.S. 1ft- 5.95in (0.456m)
A.P. 1ft- 5.95in (0.456m)

TABLE 6-4

ACB LIGHTER
TRIM & STABILITY SUMMARY
LIGHTSHIP

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	105.55	5.000	60.000A	0.000	
3% Wgt. Margin	3.17	5.000	60.000A	0.000	0.00
Containers	0.00	0.000	60.000A	0.000	
Misc. Weight	0.00	0.000	60.000A	0.000	0.00
TOTALS	108.72	5.000	60.000A	0.000	0.00

STABILITY CALCULATION

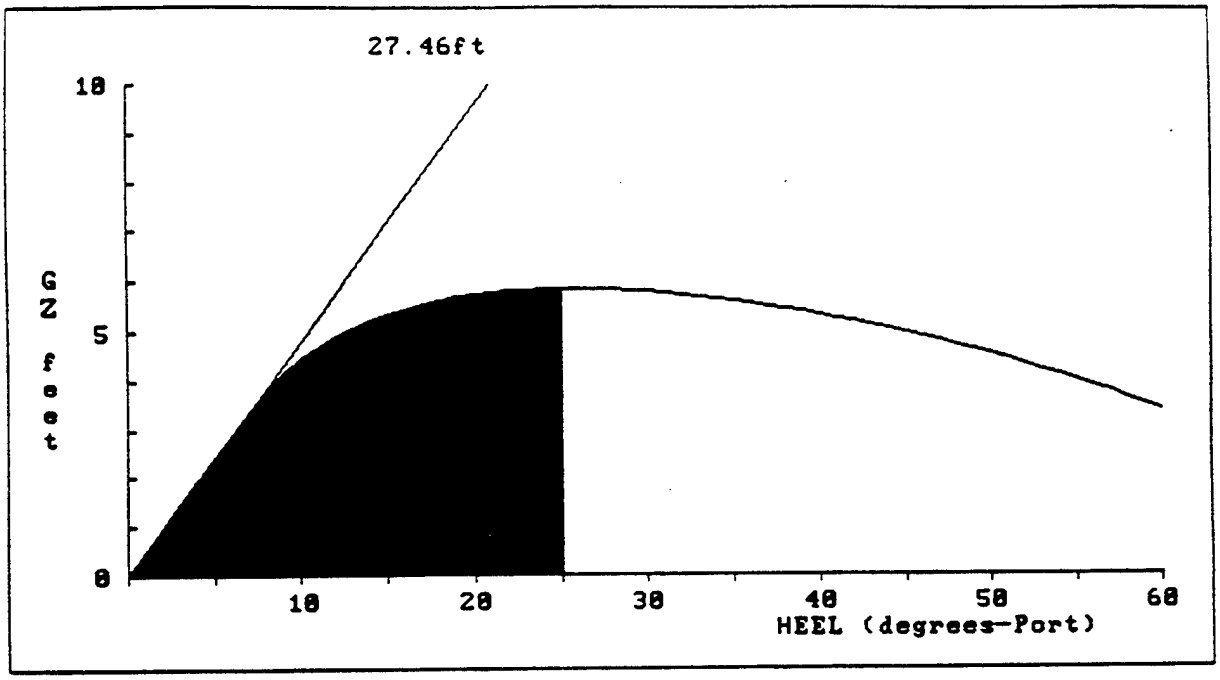
KMt	32.461 ft
VCG	5.000 ft
GMt	27.461 ft
F.S. Correction	0.000 ft
GMt Corrected	27.461 ft

TRIM CALCULATION

LCF Draft	1.610 ft
LCB (even keel)	60.00 ft-AFT
LCF	60.000 ft-AFT
MT1in	44 ft-LT/in
Trim	0.000 ft
List	0.00 deg

DRAFTS

F.P. 1ft- 7.32in (0.491m)
M.S. 1ft- 7.32in (0.491m)
A.P. 1ft- 7.32in (0.491m)



Angle of Heel	0.00 deg
Angle at Maximum GZ	25.51 deg
Area to 25.51 degrees	108.416 ft-deg
Maximum GZ	5.851 ft

STATICAL STABILITY
LIGHTSHIP

FIGURE 6-2

TABLE 6-5

RAKED MODULE
TRIM & STABILITY SUMMARY
LS & TRIMMING WEIGHT

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	33.14	5.100	21.950A	0.000	
3% Wgt. Margin	0.99	5.100	21.950A	0.000	0.00
Deck Weight	7.40	10.000	38.000A	0.000	0.00
TOTALS	41.53	5.973	24.810A	0.000	0.00

STABILITY CALCULATION

KMt	25.563	ft
VCG	5.973	ft
GMt	19.590	ft
F.S. Correction	0.000	ft
GMt Corrected	19.590	ft

TRIM CALCULATION

LCF Draft	2.016	ft
LCB (even keel)	24.80	ft-AFT
LCF	24.302	ft-AFT
MT1in	4	ft-LT/in
Trim	0.004	ft-AFT
List	0.00	deg

DRAFTS

F.P. 2ft- 0.16in (0.614m)
M.S. 2ft- 0.19in (0.614m)
A.P. 2ft- 0.21in (0.615m)

TABLE 6-6

CENTER MODULE
TRIM & STABILITY SUMMARY
LS & EQ DECK WEIGHT

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	39.27	4.840	20.000A	0.000	
3% Wgt. Margin	1.18	4.840	20.000A	0.000	0.00
Deck Weight	14.25	10.000	20.000A	0.000	0.00
TOTALS	54.70	6.184	20.000A	0.000	0.00

STABILITY CALCULATION

KMt	25.217	ft
VCG	6.184	ft
GMt	19.033	ft
F.S. Correction	0.000	ft
GMt Corrected	19.033	ft

TRIM CALCULATION

LCF Draft	2.013	ft
LCB (even keel)	20.00	ft-AFT
LCF	20.000	ft-AFT
MT1in	8	ft-LT/in
Trim	0.000	ft
List	0.00	deg

DRAFTS

F.P. 2ft- 0.15in (0.613m)
M.S. 2ft- 0.15in (0.613m)
A.P. 2ft- 0.15in (0.613m)

TABLE 6-7

ACB LIGHTER
TRIM & STABILITY SUMMARY
FULL LOAD CONTAINERS
(SEE NOTE)

ITEM	WEIGHT LTons	VCG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	105.55	5.000	60.000A	0.000	
3% Wgt. Margin	3.17	5.000	60.000A	0.000	0.00
Containers	260.00	12.250	60.000A	0.000	
Misc. Weight	0.00	0.000	60.000A	0.000	0.00
TOTALS	368.72	10.112	60.000A	0.000	0.00

STABILITY CALCULATION

KMt	13.173 ft
VCG	10.112 ft
GMt	3.060 ft
F.S. Correction	0.000 ft
GMt Corrected	3.060 ft

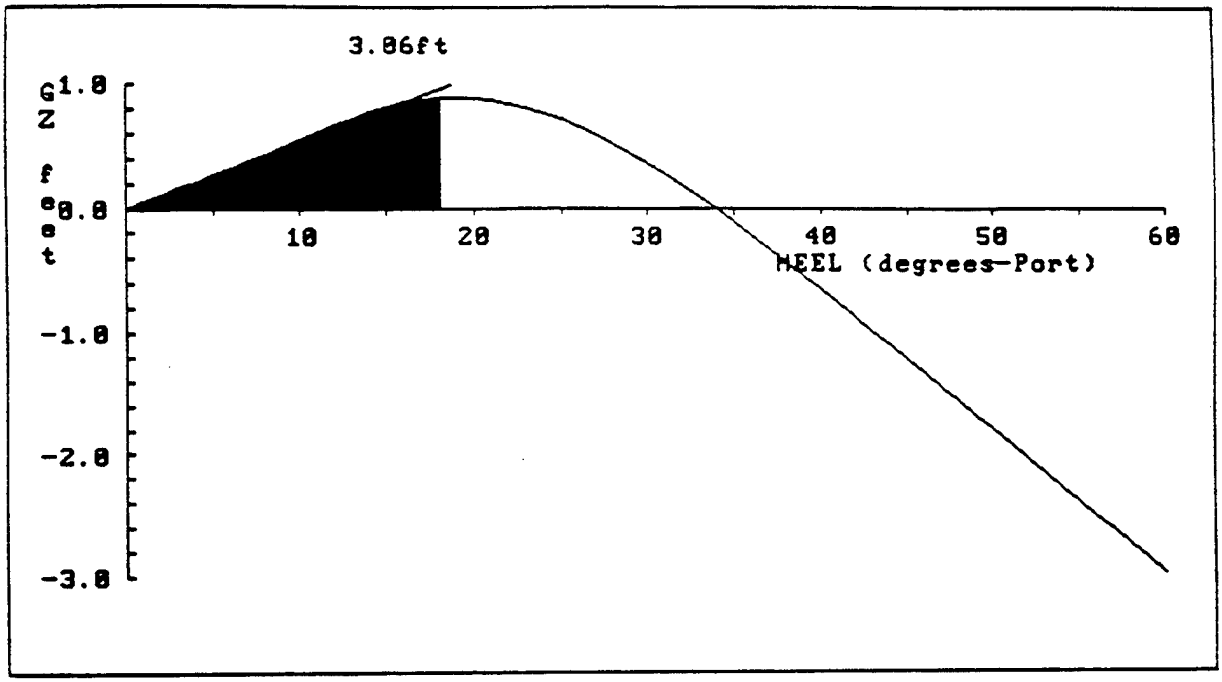
TRIM CALCULATION

LCF Draft	5.021 ft
LCB (even keel)	60.00 ft-AFT
LCF	60.000 ft-AFT
MT1in	65 ft-LT/in
Trim	0.000 ft
List	0.00 deg

DRAFTS

F.P. 5ft- 0.26in (1.530m)
M.S. 5ft- 0.26in (1.530m)
A.P. 5ft- 0.26in (1.531m)

Note: - 13 ISO-1CC (20 foot) Containers @ 20 LT each



Angle of Heel	0.00 deg
Angle at Maximum GZ	18.90 deg
Area to 18.90 degrees	9.533 ft-deg
Maximum GZ	0.896 ft

STATICAL STABILITY
FULL LOAD CONTAINERS

FIGURE 6-3

TABLE 6-8

USCG WEATHER DETAILED RESULTS
FULL LOAD CONTAINERS

Wind Pressure	0.0051	LT/ft2
Deck Cargo Lateral Area	894.40	ft2
Deck Cargo Center of Lateral Area	12.250	ft-BL
Deck At Edge Height	8.000	ft-BL
Deck At Edge Half-Breadth	12.000	ft-CL

Draft ft	Disp. LTons	Hull Lat Area Above Wl ft2	Hull V Center Above Wl ft-BL	Total Lat Area Above Wl ft2	Total V Center Above Wl ft-BL	Dist Btwn Centers ft	Angle deg	Minimum GMt ft
2.000	136.69	694.06	5.069	1,588.46	9.112	8.095	14.0	1.924
2.250	154.89	667.63	5.185	1,562.03	9.230	8.084	13.5	1.736
2.500	173.27	640.94	5.302	1,535.34	9.350	8.074	12.9	1.592
2.750	191.84	613.98	5.420	1,508.39	9.470	8.065	12.3	1.479
3.000	210.58	586.76	5.538	1,481.16	9.591	8.056	11.8	1.387
3.250	229.49	559.28	5.656	1,453.68	9.713	8.048	11.2	1.314
3.500	248.56	531.53	5.775	1,425.93	9.836	8.041	10.6	1.255
3.750	267.83	503.51	5.895	1,397.92	9.961	8.035	10.0	1.208
4.000	287.23	475.24	6.015	1,369.64	10.087	8.029	9.5	1.172
4.250	306.90	446.69	6.136	1,341.09	10.213	8.024	8.9	1.145
4.500	326.75	417.88	6.257	1,312.28	10.342	8.020	8.3	1.127
4.750	346.77	388.81	6.379	1,283.21	10.471	8.018	7.7	1.117
5.000	366.98	359.47	6.502	1,253.87	10.602	8.016	7.1	1.118
5.250	387.37	329.87	6.626	1,224.27	10.735	8.015	6.5	1.128
5.500	407.94	300.00	6.750	1,194.40	10.869	8.016	5.9	1.149
5.750	428.57	270.00	6.875	1,164.40	11.004	8.018	5.4	1.185
6.000	449.23	240.00	7.000	1,134.40	11.139	8.021	4.8	1.240
6.009	450.00	238.88	7.005	1,133.28	11.144	8.022	4.7	1.242

Distance Between Centers taken between centers of the lateral areas above and below the water line

Angle is the angle of heel at which one-half the freeboard to the deck edge is immersed or 14 degrees, whichever is less

TABLE 6-9

MINIMUM REQUIRED GMt
FULL LOAD CONTAINERS

STATICAL STABILITY
per USCG Modified Weather Criterion

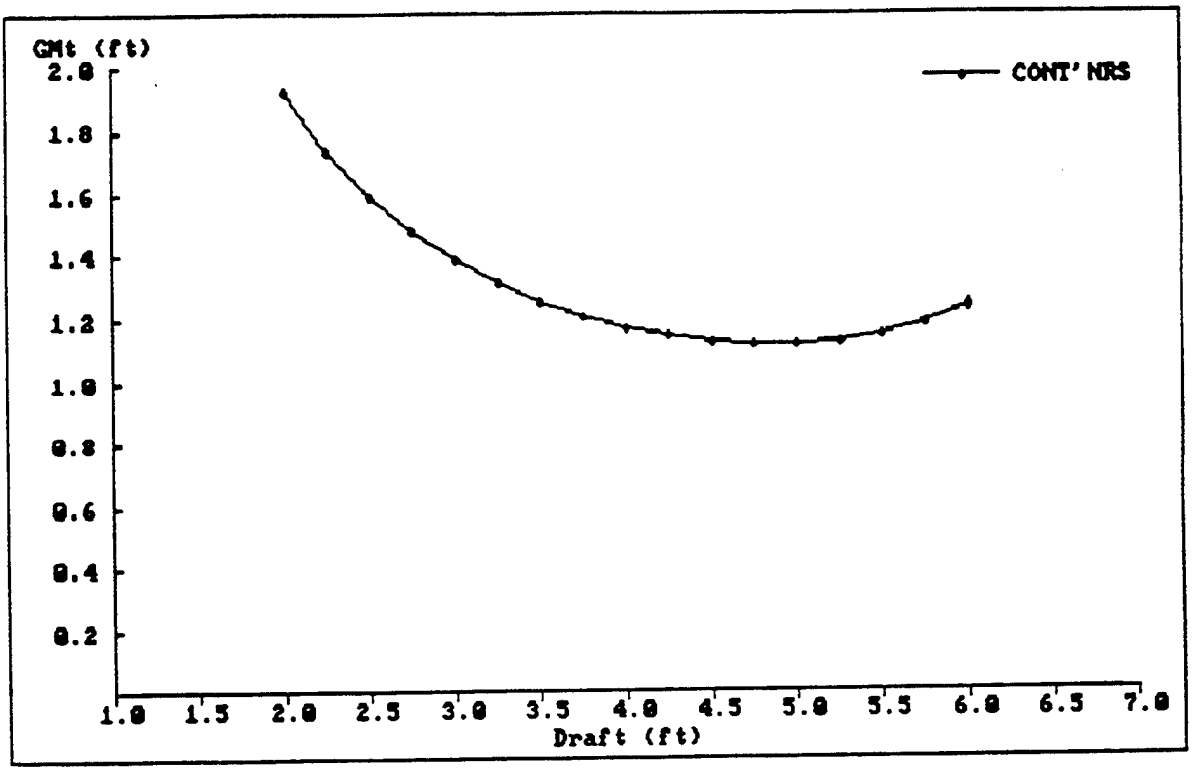
FULL LOAD CONTAINERS

Heel resulting from steady wind pressure:

GMt (corrected)	=	3.060	ft
Mean Draft	=	5.021	ft
Projected Area (Hull)	=	356.913	ft2
Vertical Arm (Hull)	=	6.513	ft
Projected Area (Cargo)	=	894.400	ft2
Vertical Arm (Cargo)	=	12.250	ft
Steady Wind Pressure	=	0.0051	LT/ft2
Displacement	=	368.72	LTons
Wind Heeling Lever	=	0.139	ft
Angle of Heel	=	2.61	deg (based on GMt)
Angle of Heel	=	2.64	deg (based on GZ curve)

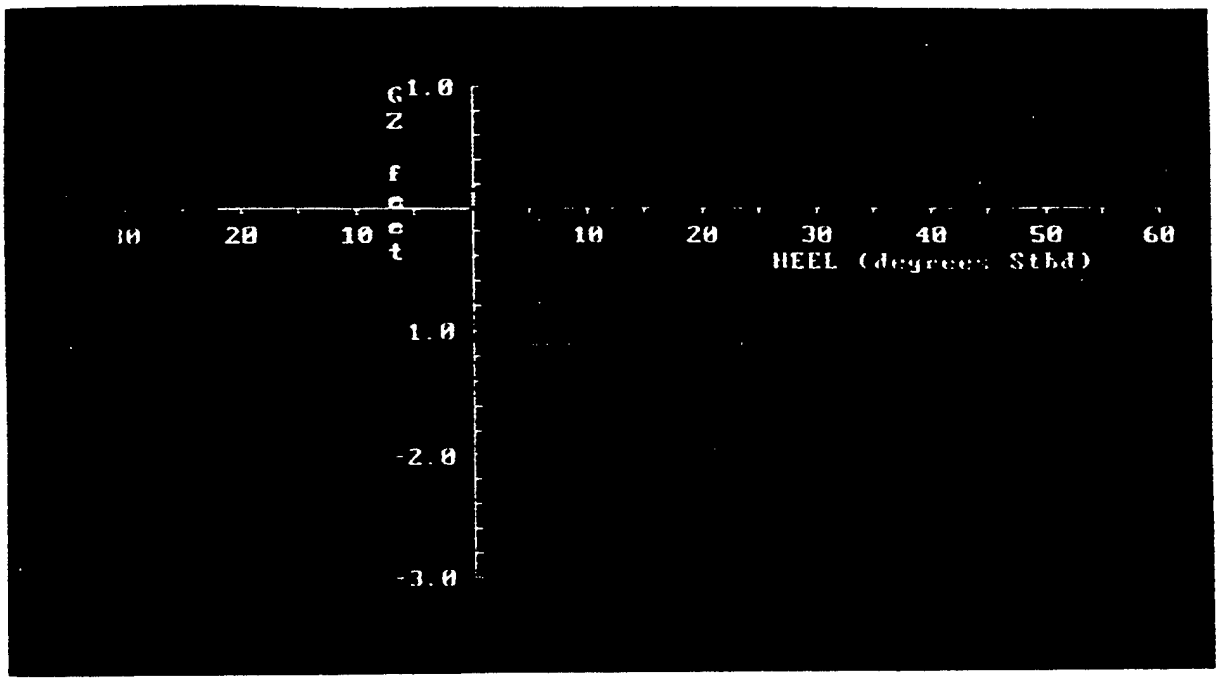
Permissible angle of heel:

Freeboard to deck edge	=	2.979	ft
Heel to 1/2 freeboard	=	7.07	deg
Permissible heel angle	=	7.07	deg



MINIMUM REQUIRED GMt
FULL LOAD CONTAINERS

FIGURE 6-4



	Available	Required
Wind Heeling Arm Lw	0.154 ft	
Maximum Righting Arm	0.896 ft	0.257 ft
Capsizing Area A2	15.800 ft-deg	
Righting Area A1	13.692 ft-deg	22.120 ft-deg

Wind Velocity	=	60 knots	Mean Draft	=	5.021 ft
Wind Pressure Factor	=	0.0035	Displacement	=	368.72 LTons
Wind Pressure	=	0.0056 LT/ft2	GMt (corrected)	=	3.060 ft
Projected Sail Area	=	1248.76 ft2	Roll Angle	=	25.0 deg
Vertical Arm	=	10.625 ft ABL			
Heeling Arm at 0 deg	=	0.155 ft	Angle at Intercept	=	32.7 deg
Wind Heel Arm Lw	=	0.154 ft	Maximum GZ	=	0.896 ft
Wind Heel Angle	=	2.9 deg	Angle at Max. GZ	=	18.9 deg

BEAM WIND WITH ROLLING STABILITY EVALUATION (PER U.S. NAVY DDS079-1) FULL LOAD CONTAINERS

FIGURE 6-5

7.0 40 FT ISO CONTAINER SIZE SUBMODULES FOR ACB LIGHTER

The primary focus of this study was the development of the 24 ft wide by 40 ft long by 8 ft deep ACB Lighter modules.

At the request of NFESC Code ESC 31, MR&S made a brief investigation of a new emerging idea of constructing the 24 ft wide ACB Lighter modules from three 8 ft wide by 40 ft long by 8 ft deep submodules. The advantage of such approach is that the submodules would be completely ISO compatible for transportation and handling. Individual submodule weights (structure and outfitting) can surely be assumed to be well below the 30 long ton handling weight limit. Due to the compartmention. this approach require more structure, and more connector and handling fittings. Furthermore the submodules would have to be preassembled into 24 ft wide by 40 ft long ACB modules (Figures 7-1, 7-2, 7-3 and 7-4) prior to loading them into container guides for transportation to LOTS sites. Each 24 ft wide by 40 ft long ACB Lighter module would comprise of three submodules.

Based on the preliminary design criteria developed for the 24 ft wide modules in this study, and summarized in Tables 3-5.8 and 3-5.9 for the center and raked modules, respectively. MR&S also calculated preliminary scantling weights for the submodules. The result are shown in Table 7-1 and 7-2 for the full depth and raked submodules. The estimated scantling weight for a ACB center module (Figures 7-1 & 7-2) constructed from three submodules would be about 76,881 lbs without allowance for painting, welding and mill tolerances. This is 18,470 lbs heavier than the 58,411 lbs (Table 3-5.8) estimated scantling weight for the 24 ft wide monocoque construction center module.

Similarly the raked module (Figures 7-3 and 7-4) constructed from three submodules would be 16,577 lbs heavier than the 54,811 lbs (Table 3-5.8) estimated scantling weight for the 24 ft wide monocoque construction raked module.

While the individual submodules weights including scantling and outfitting, will be below the 30 long ton handling limit, the transportation weight of a 24 ft wide ACB Lighter module assembled from submodules will fare exceed the 30LT handling limit. Thus the assembled modules can only be handled by the heavy cranes of the T-ACS when loading or offloading. The many other aspects of this viable concept which needs in depth investigation, is beyond the scope of this Phase I study and would require the performance of additional studies.

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TABLE 7-1
ACB LIGHTER ISO CONT SIZE SUBMODULE (FULL DEPTH)(*)
(8FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON
ABS RIVER BARGE RULES (**) (REFERENCE 4) MODIFIED AS INDICATED

DECK LONGITUDINAL SPACING 24" - TRANSVERSE FRAMING 10FT

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions t (in)	W (ft)	L (ft)	Stiffener L (ft)	Conversion Factor	Total Wt. (lbs)	From Bott VCG (FT)	From Transv CL LCG (FT)	From Longl CL TCG (FT)
1	***Deck Plate 1/4"***	0.25	8	40		40.8	3264	8	0	0
2	Side Plate 1/4"	0.25	8	40		40.8	6528	4	0	0
1	Bottom Plate 1/4"	0.25	8	40		40.8	3264	0	0	0
2	End Plate 1/4"	0.25	8	8		40.8	1306	4	0	0
3	Deck Long'l 16 x 5.5 x 26# I/T				40	19.4	2328	8	0	0
8	Side Long'l 5 x 3 1/2 x 1/4				40	7	2240	4	0	0
3	Bottom Long'l 5 x 3-1/2 x 5/16 L				40	8.7	1044	0	0	0
6	End Stiff, 5 x 3-1/2 x 3/8 L				6	10.4	374	4	0	0
4	End Stiff 16 x 5.5 x 26# I/T				5	19.4	388	4	0	0
4	Deck Transv 16 x 7 x 36# I/T				8	26.45	846	8	0	0
12	Side Transv 10 x 4 x 19# I/T				5	8.93	536	4	0	0
4	Btm Transv 16 x 5.5 x 26# I/T				8	19.4	621	0	0	0
2	Long'l Edge Capping 16 x 5.5 x 26# I/C				40	19.4	1552	8	0	0
2	Transv Edge Capping 10 x 4 x 19# I/C				8	8.93	143	8	0	0
8	Diagonals 6 X 4 X 12 # I				11	8.5	748	4	0	0
2	***No Plt iwo Diag of transv bhd***	-0.188	0.5	22		40.8	-169	4	0	0
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	8		40.8	614	4	0	0

A.	TOTAL ESTIMATED SCANTLING WT:		25627	4.50	0.00	0.00
B.	40FT ISO CONT. GROSS WT (30LT):		67200			
C.	DELTA WT = (A-B):	(-)	41573 (***)			
D.	DELTA WT = IN % OF B:	(-)	61.18 (***)			

NOTES:
(*) ISO CONT SIZE SUBMODULE FOR THE ACB LIGHTER CENTER MODULE ASSEMBLY (SEE FIGURES 7-1 & 7-2)
(**) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(***) VALUES INDICATED WITH (-) ARE UNDER THE 40FT ISO CONT. GROSS WT (B)

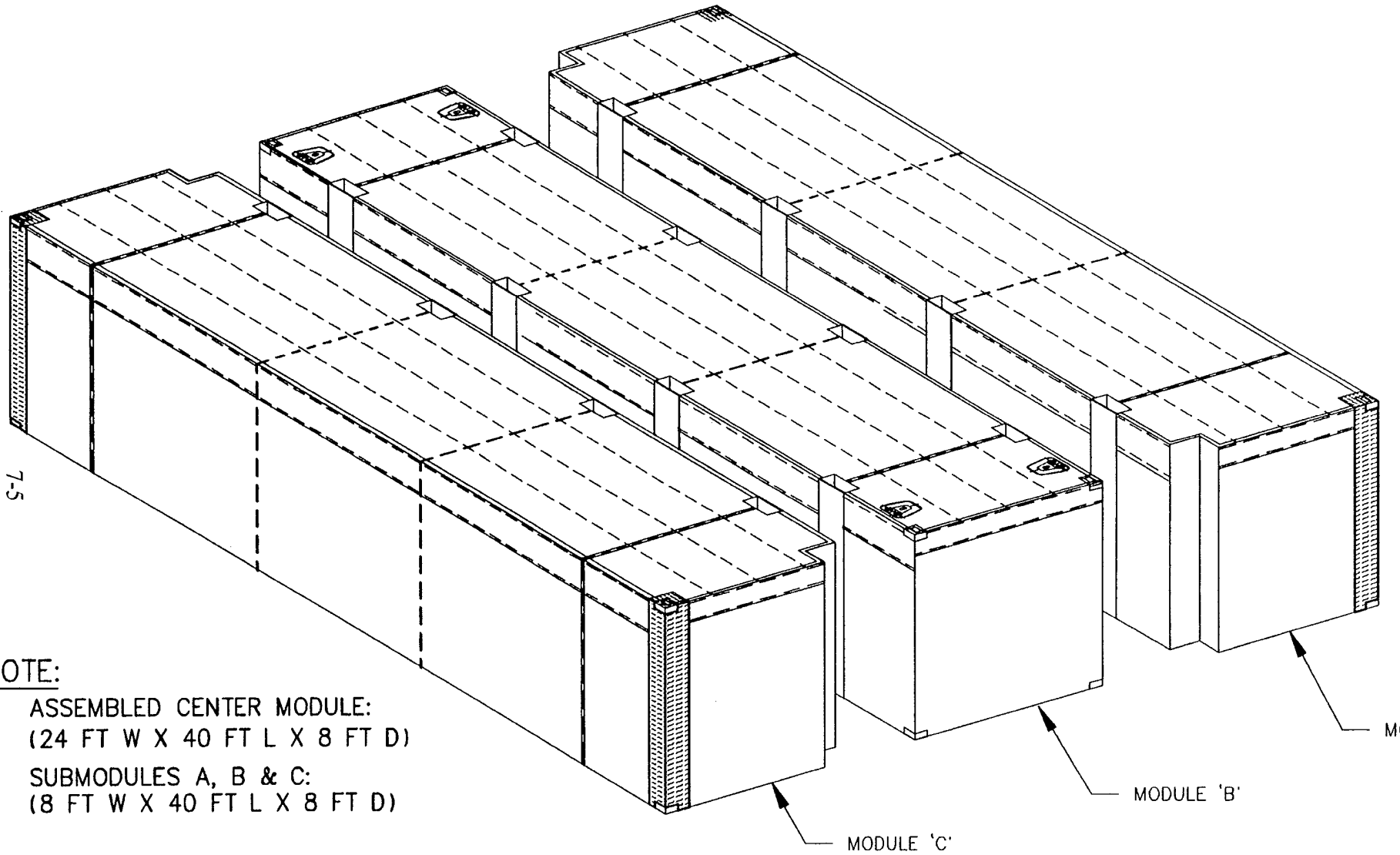
TABLE 7-2
ACB LIGHTER ISO CONT SIZE SUBMODULE (RAKED)(*)
(8FT W X 40FT L X 8FT D)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
ABS RIVER BARGE RULES (**) (REFERENCE 4) MODIFIED AS INDICATED
DECK LONGITUDINAL SPACING 24" - TRANSVERSE FRAMING 10FT

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

Qty	Description	Plate Dimensions t (in)	W (ft)	L (ft)	Stiffener L (ft)	Conversion Factor	Total Wt. (lbs)	From Bott VCG (FT)	From 8' Depth End LCG (FT)	From CL TCG (FT)
1	***Deck Plate 1/4"***	0.25	8	40		40.8	3264	8	20	0
2	Side Plate 1/4"	0.25	8	26.33		40.8	4297	4	13.4	0
2	Side Plate 1/4"	0.25	5.25	13.67		40.8	1464	5.33	33.4	0
1	Bottom Plate 1/4"	0.25	8	40		40.8	3264	0	20	0
1	End Plate 1/4"	0.25	8	8		40.8	653	4	0	0
1	End Plate 1/4"	0.25	2.5	8		40.8	204	6.75	40	0
3	Deck Long'l 16 x 5.5 x 26# I/T				40	19.4	2328	8	20	0
8	Side Long'l 5 x 3 1/2 x 1/4 L				26.33	7	1474	4	13.4	0
8	Side Long'l 5 x 3-1/2 x 1/4 L				8.09	7	453	5.33	33.4	0
3	Bottom Long'l 5 x 3 1/2 x 5/16				40	8.7	1044	0	20	0
3	End Stiff 5 x 3-1/2 x 3/8 L				6	10.4	187	4	0	0
3	End Stiff 5 x 3-1/2 x 3/8 L					10.4	78	6.75	40	0
2	End Stiff 16 x 5.5 x 26# I/T				5	19.4	194	4	0	0
2	End Stiff 16 x 5.5 x 26# I/T	2.5			2.5	19.4	97	6.75	40	0
4	Deck Transv 16 x 7 x 36# I/T				8	26.45	846	8	20	0
8	Side Transv 10 x 4 x 19# I/T				5	8.93	357	4	11.25	0
4	Side Transv 10 x 4 x 19# I/T				3.25	8.93	116	6.75	35	0
4	Btm Transv 16 x 5.5 x 26# I/T				8	19.4	621	0	20	0
2	Long'l Edge Capping 16 x 5.5 x 26# I/C				40	19.4	1552	8	20	0
2	Transv Edge Capping 10 x 4 x 19# I/C				8	8.93	143	8	20	0
6	Diagonals 6 X 4 X 12 # I				11	8.5	561	8	15	0
2	Diagonals 6 x 4 x 12# I				9	8.5	153	6.75	35	0
2	***No Plt iwo Diag of transv bhd***	-0.188	0.5	22		40.8	-169	4	25	0
2	***WT Transv Bulkhead Plates 3/16"***	0.188	5	8		40.8	614	4	15	0

A.	TOTAL ESTIMATED SCANTLING WT:	23796	4.82	18.68	0.00
B.	40FT ISO CONT. GROSS WT (30LT):	67200			
C.	DELTA WT = (A-B):	43404 (***)			
D.	DELTA WT IN % OF B:	64.58 (***)			

NOTES:
(*) ISO CONT SIZE SUBMODULE FOR THE ACB LIGHTER CENTER MODULE ASSEMBLY (SEE FIGURES 7-3 & 7-4)
(**) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH)
(***) VALUES INDICATED WITH (-) ARE UNDER THE 40FT ISO CONT. GROSS WT (B)



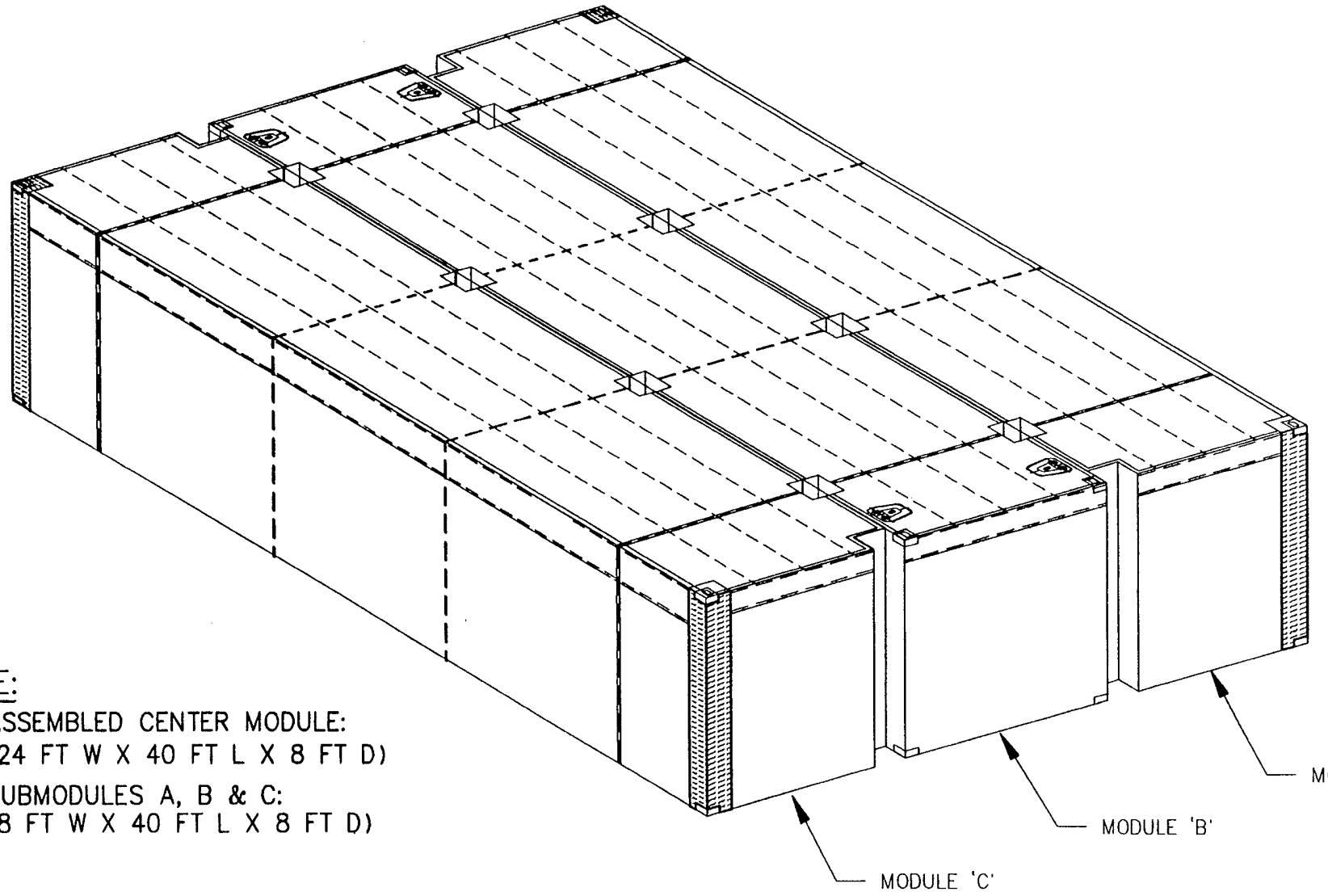
NOTE:

ASSEMBLED CENTER MODULE:
(24 FT W X 40 FT L X 8 FT D)

SUBMODULES A, B & C:
(8 FT W X 40 FT L X 8 FT D)

ISO CONTAINER SIZE SUBMODULES (A, B & C) FOR ACB-LIGHTER CENTER MODULE ASSEMBLY ISOMETRIC VIEW

FIGURE 7-1



NOTE:

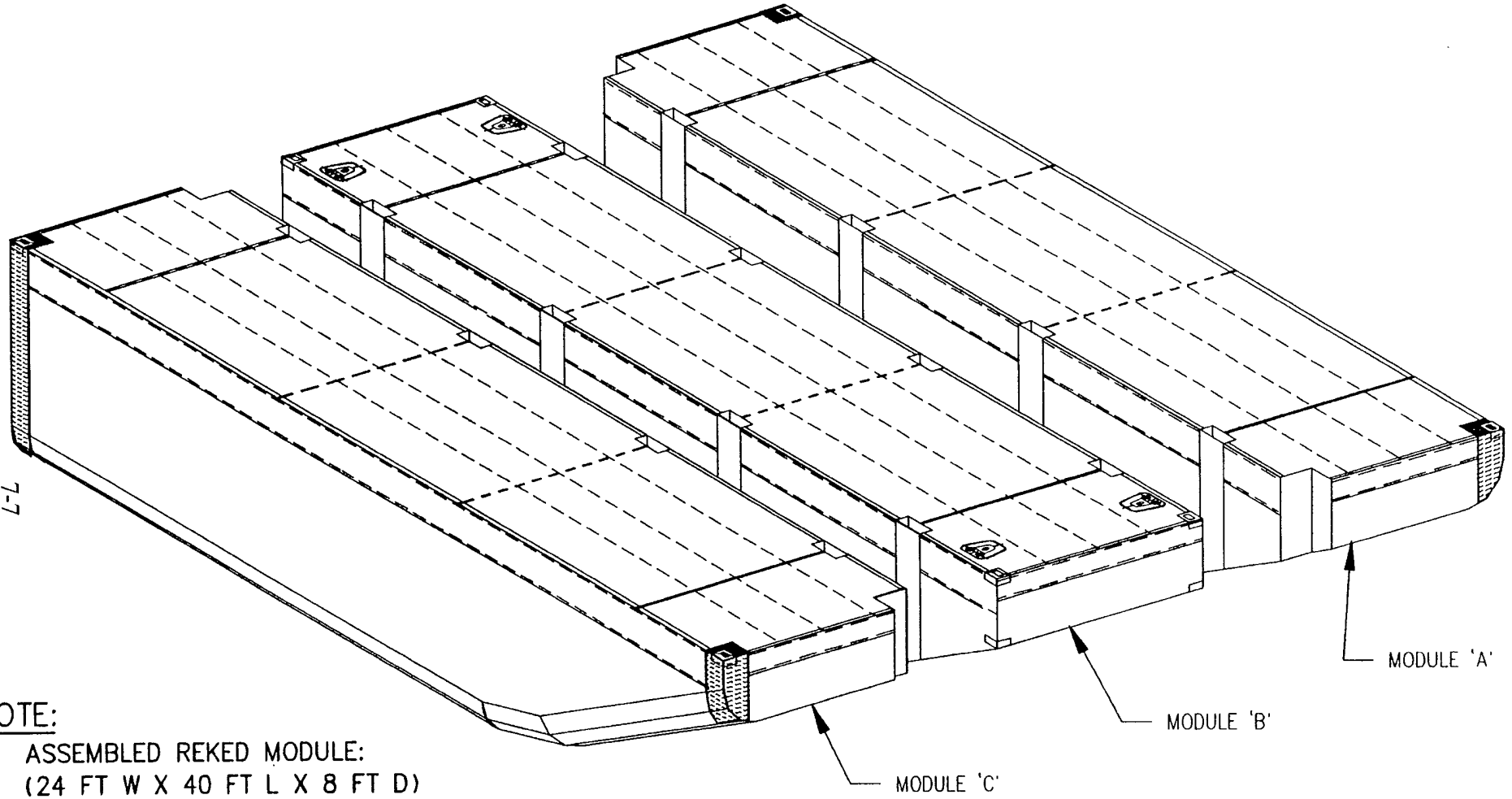
ASSEMBLED CENTER MODULE:
(24 FT W X 40 FT L X 8 FT D)

SUBMODULES A, B & C:
(8 FT W X 40 FT L X 8 FT D)

ACB-LIGHTER CENTER MODULE ASSEMBLED FROM ISO CONTAINER SIZE SUBMODULES (A, B & C)

ISOMETRIC VIEW

FIGURE 7-2



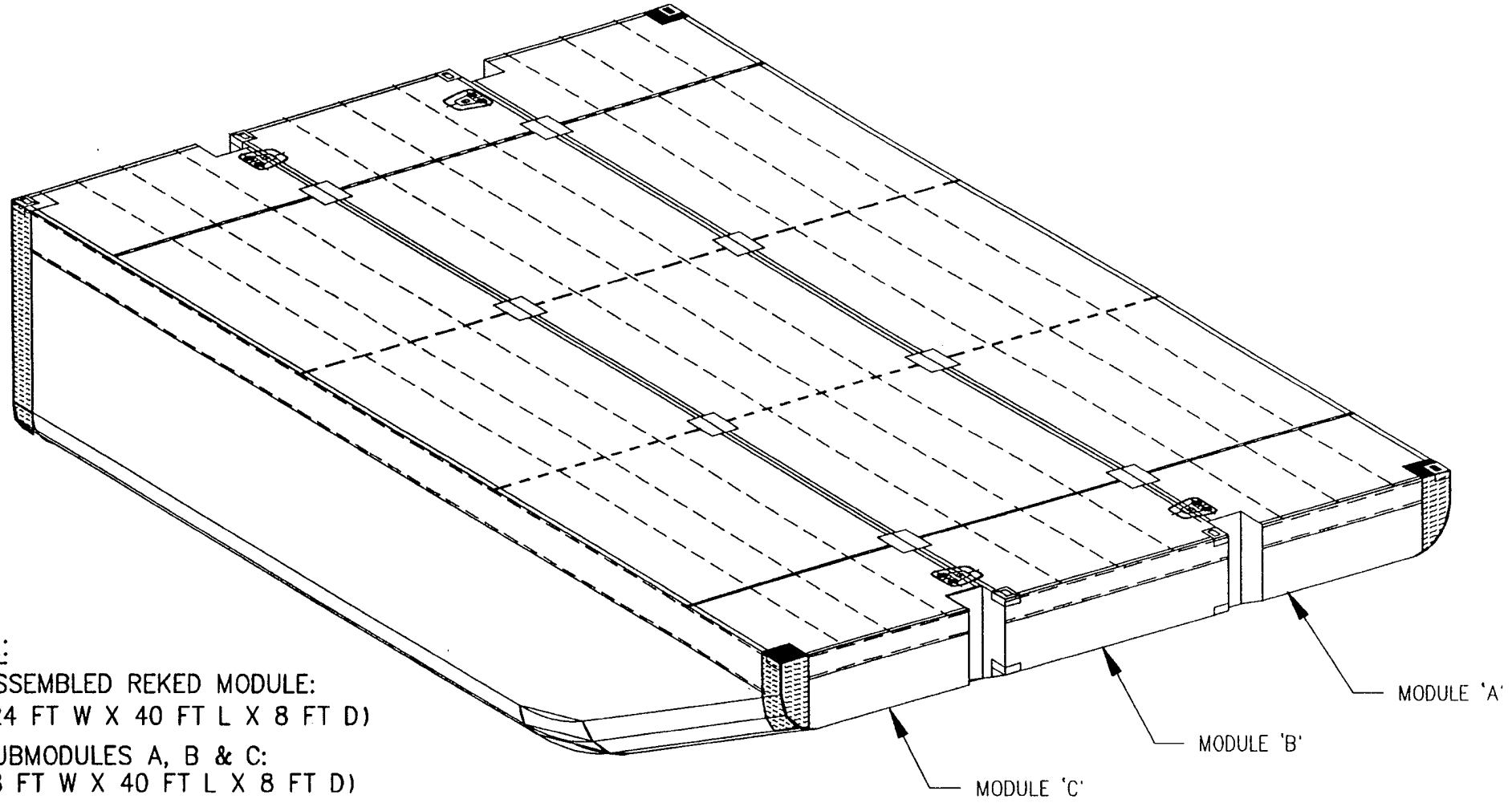
NOTE:

ASSEMBLED REKED MODULE:
(24 FT W X 40 FT L X 8 FT D)

SUBMODULES A, B & C:
(8 FT W X 40 FT L X 8 FT D)

ISO CONTAINER SIZE SUBMODULES (A, B & C) FOR ACB-LIGHTER RAKED MODULE ASSEMBLY ISOMETRIC VIEW AT RAKED END

FIGURE 7-3



NOTE:

ASSEMBLED REKED MODULE:
(24 FT W X 40 FT L X 8 FT D)

SUBMODULES A, B & C:
(8 FT W X 40 FT L X 8 FT D)

ACB-LIGHTER RAKED MODULE ASSEMBLED FROM ISO CONTAINER SIZE SUBMODULES (A, B & C) ISOMETRIC VIEW AT RAKED END

FIGURE 7-4

8.0 SUMMARY AND RECOMMENDATIONS

8.1 Summary

This report documents the results of a first phase effort by M. Rosenblatt & Son, Inc. (MR&S) which addressed several critical issues germane to the Advanced Modular Lighterage/Development Program. The key building block of this program is the modular Amphibious Cargo Beaching (ACB) Lighter, being developed by the Naval Facilities Engineering Service Center (NFESC).

The new ACB Lighter is to overcome the many limitations that the existing Navy's NL and the Army's MCS systems have in cargo capacity, freeboard, transportability and operating capability in higher than Sea State 2 weather condition. The new ACB Lighter will be able to operate in Sea State 3 weather condition. Transportability of the new system will be greatly improved by the modular design whereby the 120 ft long by 24 ft wide by 8 ft deep ACB Lighter will be assembled from three 40 ft long modules. The 40 ft modules will be capable of being transported and stacked in 40 ft container cell guides of a containership.

As a key design objective for the handling, transportation and stacking of the modules, the maximum gross handling weight (structure, attached fittings and connector assemblies) for each module was set at 30 long tons (67,200 lbs) the same as the maximum gross weight of a standard 40 ft ISO container.

Under this contract MR&S has been tasked by NFESC Code ESC31 to address the following critical issues:

- o Development of design criteria for ACB Lighter Module Structure which can be used to design the lightest possible module/lighter structure for the specified service and loads.

- o Develop requirements for handling, transportation and stacking of the modules in standard 40 ft container guides.

This first phase study concentrated on the development and evaluation of the various applicable options for efficient and lightweight structural design, outfitting, handling, transportation and stacking of the ACB lighter modules.

The main results of this first phase effort can be summarized as follows:

a. Preliminary Design Criteria for ACB Lighter Scantlings

   The review of the selected hull design codes and procedures (References 2 through 7) indicates that selection of the ABS River Rules (Reference 3) with modifications would yield the lightest module scantling weight.

The modifications to the ABS Rules include the acceptance of the Jackson & Frieze design procedure (Reference 7) for deck plating design. The procedure allows the use of 1/4 inch high strength steel plating with 1/4 inch permanent plate deformation between stiffeners under the specified wheel load of the RTCH. The ABS Rules would require the use of a 5/8 inch thick deck plating for the specified wheel load.

The other proposed modification to the rules would be using 3/16 inch plating for the longitudinal and transverse watertight bulkheads. ABS Rules require 1/4 inch plating.

b. Scantling Weights

The estimated scantling weight of the ACB Lighter Center Module based on the above criteria is 58,411 lbs (see Table 3-5.8). The weight limit for the module hoisting weight is 67,200 lbs therefore the remaining 8,789 lbs can be allocated for fittings and connectors. The estimated scantling weight of the ACB Lighter "Raked" Module based on the above criteria is 54,811 lbs (see Table 3-5.9). The weight limit for the module hoisting weight is 67,200 lbs therefore the remaining 12,389 lbs can be allocated for fittings and connectors.

c. Module Weights

Despite considerable progress made in developing the preliminary structural design criteria for the ACB lighter modules, this first phase development effort could not achieve the 67,200 lbs maximum allowable weight limit for the lighter module(s). As shown in Tables 3-7.1 and 3-7.2 the total estimated module weights (scantling and fittings) are 87,975 and 75,031 lbs for the center and raked ACB lighter modules respectively. Therefore, the estimated center and raked module weights exceed the 67,200 lbs allowable weight limit by 20,775 lbs and 7,831 lbs respectively.

It must be emphasized that the above module weights include the NFESC estimated weights for the module connector assemblies. The total included connector assembly weights are 24,000 lbs for the center module and 12,000 lbs for the raked module. The design development of the ACB lighter connector assemblies is expected to be completed in the near future by NFESC and others under separate contract. The present weight estimates for the connector are considered to be very preliminary and on the high side.

While the above weight results appear to be highly unfavorable and would tend to eliminate the possibility of utilizing existing standard container cranes, spreads and container trailers for module handling, MR&S believes that a future second phase development effort which would develop and implement the recommended action items for weight reduction would bring the module weights down to the maximum allowable limit of 67,200 lbs. (See paragraph 8.2 for recommendations).

d. Module Fittings, Handling, Stacking and Transportation of Modules

The following additional issues were studied during the first phase effort:

- o Required fittings for handling, stacking, cargo tie down and mooring were selected. Fitting arrangements, quantities, sizes and capacitates were recommended.
- o Requirements for ACB Lighter Module interface with container guides and stacking were developed.
- o Module handling and inside terminal transportation scenarios were developed and module interface with standard container handling cranes/spreaders and trailers were investigated.

Assuming that a second phase development effort will be performed and very likely the module handling weight will be reduced to the 67,200 lbs limit, the first phase studies in this report indicate that the 40 ft long by 24 ft wide by 8 ft deep ACB Lighter Modules can be:

- o Interfaced with standard 40 ft container guides.
- o Stacked up to six high in container holds with a minimum of three adjacent container cells.
- o Handled in container terminals with standard container cranes and spreaders.
- o Transported by standard container trailers within a terminal.
- o Handled (loaded into holds or launched over the side) with the heavy lift cranes of the T-ACS using a four point cargo sling.

8.2 Recommendations for Phase II Scope of Work

The Phase II weight reduction objectives for the center and raked modules of the ACB Lighter are as follows:

o Center Module:	87,975 lbs (Phase I wt)
o Required Phase II Reduction:	(20,775 lbs)
o Phase II Weight Objective:	67,200 lbs

o Raked Module	75,031 lbs (Phase I wt)
o Required Phase II Reduction:	(7,831 lbs)
o Phase II Weight Objective:	67,200 lbs

In order to achieve the required weight reduction objectives the following options should be considered:

a. Module Structural Design

Verify that the following changes (*) to the preliminary hull design criteria for the ACB Lighter scantlings would result in an estimated weight reduction of 5,000 lbs for a 24 ft wide by 40 ft long and 8 ft deep center module:

- o Retain the same design premise for the platings as proposed in Phase I, basically following the ABS River Rules, with the Jackson and Frieze paper used for the deck plate design assuming the RTCH as the design load. The internal bulkhead thickness plating would also remain at 3/16 inch as in Phase I.

- o* Design the framing members and stiffeners with a 20% higher allowable stress than the ABS River Rules permit. This would be achieved by decreasing the section modules and the shear areas of these members by 20%.

- o* Design the webs and flanges so that their critical buckling strength is very near to the yield strength of the material.

It is suggested that MR&S and NFESC review these proposed changes to the current design criteria for hull structure and develop a final criteria for the lightest possible scantling design.

b. Module Hull Depth Reduction

Consider reduction of the module hull depth by 6 inches to 7'-6" from the present 8'-0" depth. Estimated weight saving per module: 1,200 lbs.

c. Fittings

- o Use raised cargo tie down fittings vs. flush fittings. The estimated weight saving per module: 216 lbs. Verify the 35,000 lbs recommended fitting rating (Phase I) by load analysis on tie-down fittings in sea state 5 operating condition.

- o Use removable type mooring cleats. Estimated weight saving per module: 1,400 lbs. Develop quick attachment/removal concept for cleat installation to eliminate the need for bolted cleat connection.

- o Use two side connector assemblies on the center module vs. the four used in Phase I. Estimated weight savings per center module: 6,000 lbs.

- o Reduce connector assembly weight by eliminating the requirement for the presently preferred modular approach by NFESC (3 ft wide by 5 ft long by 6 ft high module size and 3,000 lbs per module).

In order to meet the weight reduction target for the center module a total of 6,959 lbs weight reduction is required for the remaining six connector assemblies. The weight of each connector module will have to be reduced by 1,160 lbs to 1,840 lbs from the presently estimated assembly weight of 3,000 lbs.

- o Review the existing NFESC connector assembly design for weight reduction. Develop new concept(s) for the integration of the connector assembly components directly into the lighter structure. Provide weight saving estimate for each approach.

d. Successful implementation of the above recommendations will provide the required weight reduction for the center and "raked" modules.

e. Additional Recommendations

- o As an alternate approach to paragraph d, IF connector weights can not be reduced to the proposed 1,840 lbs per assembly as stated in paragraph 3d, an alternate approach should be considered by allowing a maximum of 2,400 lbs (3.5 % of 67,200 lbs) excess weight for the module(s). Thus, the allowable connector assembly weight could be increased to 2,240 lbs. The excess weight impact on the standard container handling equipment (crane, spreader, and trailer) needs to be evaluated.